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OVERHEAD LINES AND THE BOARD OF TRADE.

THE two memorials to the Board of Trade, copies of which were published in the correspondence columns of our last issue, show that a wide difference of opinion exists between that Department and some important manufacturing and contracting firms with regard to the precautions necessary for the erection of a safe overhead line. Whilst agreeing with the memorialists that a change is certainly necessary, we cannot help thinking that they have not made as good a case as was possible; and we hope, therefore, that if, as is probable, the Chamber of Commerce takes the matter up, it will, before addressing the Board of Trade, make an exhaustive enquiry; and by obtaining the views of all manufacturers and contractors who have had practical experience with overhead conductors, be enabled to present a strong and well-stated case. Had such a plan been followed by the committee of the Council of the Institution of Electrical Engineers, when the regulations were first submitted to them, the need for amendments so soon after the issue of the rules ought never to have arisen; but, instead of acting in this manner, a committee of gentlemen, who were either without the necessary experience, or had not sufficient personal interest in the questions involved, appear to have approved of the proposed regulations in the name of the whole trade, without ever realising in the slightest degree what it was to which they were agreeing. Naturally this approval of the regulations may be used as an argument against the proposed amendments, and it therefore behoves the trade generally to try and arrange a new *modus operandi* by which they shall secure to themselves the right of being consulted by the Board of Trade before any regulations affecting their business are promulgated.

The first memorial deals with the regulation specifying the thickness of the dielectric, and a brief consideration of the requirements of a safe overhead conductor shows that these are: (1) a sufficiently high insulation resistance to render accidents practically impossible through direct leakage, if the outer covering of the cable comes in contact with a human being or another wire; (2) a sufficient thickness of insulating material to allow of the necessary handling during erection without damage to the cable; and (3) the protection of linesmen and others from shocks due to the discharge from the exterior surface of the cable of the charge which is induced thereon.

So far as accidents from direct leakage are concerned, ample experience has been gained in working high-pressure alternating circuits underground to show that a thickness of one-tenth of an inch of insulating material, if of suitable quality, is quite unnecessary for the smaller sized conductors; and we may here draw attention to the fact that, so far as guarding against accidents from this cause is concerned, the Board of Trade regulations are quite insufficient, since they specify a uniform thickness of dielectric, irrespective of the size of the conductor, or of the nature of the insulating material employed. The only reasonable form of specification for dealing with this condition is such an one as is proposed in the memorial, viz., that the cables shall have at least a certain minimum insulation resistance per mile, when tested under the best conditions for discovering the existence of faults.

The insulation resistance proposed by the memorialists appears to us sufficiently high to meet all practical requirements, and if a clause were added specifying that during immersion the cable should be subjected to a difference of potential at least equal to that at which it is to be used, we think that no reasonable objections could be offered to the proposed amendment on the score of danger from direct leakage.

The second requirement has to do with the mechanical strength of the insulating material, and here again the experience of all work done, whether indoor or outdoor, underground or overhead, shows that small cables with much thinner insulation than that specified can withstand a considerable amount of rough usage.

Many of us have seen cables with even less than a

sixteenth of an inch of insulating material pulled into pipes, bent round corners of small radius, straightened out again, and subjected to other such treatment without injury; and, were it only this that had to be looked to, we would say that the thickness now suggested was more than was necessary; but there is another matter, which is really one for manufacturers to speak on, and is dependent on the excellence of their machinery, and the care with which their work is done, and that is the difficulty of being absolutely certain that throughout a long length of cable the covering is perfectly even and homogeneous. We believe that excellent results are now obtained in this respect, but for all that we think that, when high pressures are to be used, it is well to err a little on the safe side. A fault due to a slight unevenness in the covering would not show any perceptible difference in the measured insulation resistance; but the test at high pressure already suggested should discover it, if sufficiently bad to be in the slightest degree a cause of danger; and this test, together with the thickness of dielectric now proposed, should be a sufficient safeguard against accidents caused by mechanical faults.

Generally speaking, so far as the two conditions of safety already spoken of are concerned, there is no reason why any difference should be made between underground and overhead cables; and it is therefore, we suppose, with a view to guarding against accidents from discharge that the greater thickness of dielectric is specified. This particular source of danger does not appear to have received the consideration due to it; otherwise the attempt to get rid of it by simply thickening the insulation would not have been made. It is true that an increase in the thickness of the dielectric will decrease the discharge, other things being equal; but a far more important factor in practice is the extent of surface in electrical contact with the discharging circuit. When the outer covering of the cable is dry, and therefore the contact surface is practically limited to the amount covered, say, by a man's hand, no unpleasant results need be apprehended with the ordinary class of cable and a pressure of 2,000 volts; but should the outer covering be wet, so that the surface is a fairly good conductor, the man's hand would really be in contact with a considerable area, and an unpleasant shock would certainly result, even with cables covered with a tenth of an inch or more of insulating material. We are not aware of any exact measurements having been made; and as it is not desirable that they should be first made, when a human being is the measuring instrument, we would commend this matter to the notice of manufacturers and others, who have the necessary appliances for making tests, in the hope that they will be able to supply further information.

The insulated suspending wire, which is connected at frequent intervals by non-metallic ligaments to the outer coating of the cable, will, when these ligaments are damp, be just as unpleasant to touch as the cable itself; being, in fact, under those conditions, equivalent to a metallic sheathing. Now, we find it specified that when a metallic covering is used, that covering shall be efficiently connected to earth; and the same reasoning, which shows this to be necessary, should also require the earthing of all suspension wires. Such a course of action, by providing an easier path for a discharge than through a human body, would supply the necessary safeguards against accident.

The other regulation, to which exception is taken, is that relating to the use of suspending wires; and here we consider that a grave mistake has been made, since the Board of Trade is asked to make the use of suspending wires optional with cables where conductors are not larger than 7 No. 16; whilst no notice is taken of the regulation concerning the wind pressure to be allowed for, a regulation which, if it remains in force, will render the proposed alteration inoperative; since, as a little calculation would have shown, these smaller cables cannot be used without suspending wires for spans for anything like 200 feet, when a wind pressure of 50 lbs. per square foot, and a factor of safety of six have to be allowed for. We do not propose to enter into any discussion of this question, as in a recent issue* we printed an article on this subject by Mr. Russell, which showed how much the requirements of the Board of Trade were in excess of what has been previously considered sufficient for safe work; but we think that all efforts should be directed to getting the wind-pressure clause amended, and that until this is done it is futile to discuss the question as to whether suspending wires are necessary or not in particular cases.

In concluding our present remarks, we would congratulate the trade on the fact of some steps having now been taken to get these regulations amended; steps which, we hope, will lead to a more satisfactory arrangement. We are, however, surprised that the firms whose signatures are appended to these memorials should have been content to put their case before the Board of Trade in such a feeble manner; more especially when we consider that two of them are connected with the manufacture of cables, and should have sufficient experience to enable them to present a much more forcible memorial, and one that could not but carry great weight with it.

Galvanometers.

THE proceedings of the Physical Society recently published, contain the interesting paper of Prof. Ayrton, Mr. T. Mather and Mr. Sumpner on "Galvanometers." The whole history of this valuable and indispensable piece of electrical apparatus would form a voluminous work, and might be appropriately dealt with by that indefatigable electrical historian, Prof. Silvanus Thompson. Attention to various points of detail has vastly improved the original form of the Thomson reflecting instrument, though it is surprising how closely in general form the early patterns have been (and wisely so) adhered to. There is still room for improvement, however; the hinging of the coil frames is one most noticeable change that has been marked within the last 20 years, but we find that the absurd arrangement of bringing out the coil

* ELECTRICAL REVIEW, 24th October, p. 489.

ends near the centre of the coils is still adhered to, the result being that the coils cannot be swung on their hinges without having to disconnect the ends of the wires from the terminals to which they are attached; if this is not done the spiral connections are pulled out of shape, and in any case are made very untidy. The spiral connections ought, of course, all to be led to and brought out close to the hinges where the movement is least, and we are surprised that this has never been done.

Submarine Telephony.

IT is surprising how little the conditions for telephonic working through underground or submarine wires seem to be grasped by numerous so-called electricians; one would have imagined that the law was as well known as that of Ohm. That the product of the total capacity in microfarads and the total resistance in ohms of the line, or its "KR," must not exceed a certain value is a simple and easily recollected law. What this value is, depends upon circumstances; but its average value for good speaking is about 10,000. This figure is known to be correct as the result of numerous experiments, and it disposes of the absurd notion that some people have, that telephoning through a cable several hundred miles long is possible.

The Censorship of the Board of Trade.

A CORRESPONDENT writes:—"In the latter part of one of your leading articles entitled 'State Control,' the action of the Board of Trade with reference to electric lighting is severely criticised, but not so severely as it deserves, for that would be impossible. Your remarks would bear repetition again with special reference to the overhead wire question. I think it perfectly scandalous that after electric lighting has reached its present stage of progress by private enterprise and individual effort, the Government should step in with its grandmotherly legislation and restrictive policy and so hinder future progress. But it is always the same. Officialism does act always so, must in fact act so, though people cannot see it until by getting the Government to interefere in their affairs they make a rod for their own backs. The scientific adviser to the Board of Trade knows nothing about practical electric lighting, save what those he now dictates to have taught him, small claims, I think, for so important a position."

Projected New Telegraph Lines.

THE *South American Journal* of 29th ult. says:—"Mr. E. Barra has applied to the Government of the Argentine Republic for the privilege to build a line of telegraph from Buenos Ayres to the Cordillera, where it would join another line to the Pacific. This line is intended to compete with the Transandine Telegraph." It is also announced that the *Diario Official* of October 30th contains a ministerial resolution issued by the Department of Public Instruction, Posts and Telegraphs, authorising the Western and Brazilian Telegraph Company to lay a duplicate cable along the coast of Brazil. The Chilian Government has accepted a tender for the construction of a line of telegraph between Tongoi and Tamayo.

Insulation of Underground Lines.

AT a recent meeting of the Berlin Electro-Technical Society, M. Grawinkel read a paper on the condition of underground lines belonging to the Administration of Posts and Telegraphs of the German Empire, describing at the same time the system adopted in the various tests. In contrasting the results of tests taken during 1889 with those of former years, the author is forced to come to the conclusion that the much lower insulation observed in the gutta-percha core more recently laid down, as compared with the insulation obtained originally on the older lines, is due to nothing else but the inferior quality of the gutta-percha now employed; a consequence resulting from the enormous demand for this material.

The Testing of Insulated Wires and Cables.

THE first instalment of a series of articles under the heading of "A Practical Guide to the Testing of Insulated Wires and Cables," written by Mr. Herbert L. Webb, appears in the New York *Electrical Engineer* for November 19th, 1890. So far as the subject is at present carried, we fail to see that the treatment is in any degree more simple than that to be found in many text-books, Culley, for example, although the *raison d'être* of the article is nominally for the purpose of assisting the "budding expert" to grasp the rudiments of electrical testing. Perhaps as the matter advances we may find reason to alter our opinion. We must admit that it is rather early to come to a conclusion.

A Candid Statement.

IT is not often that a journal devoted to gas matters makes a candid statement regarding electric lighting, but the *Gas World* in its last issue has done so. In referring to the financial position of the Swan United Electric Light Company, our contemporary says:—"Go where we will, however, this fact stares us in the face, that electric light companies are getting customers in quarters where formerly gas reigned supreme. Whether they will be able to retain these customers, or whether these customers will continue to pay the high price which must be charged to earn dividends, are different questions. All we can say is, that when the two illuminants come into competition the gas shareholder does not suffer, that is, if the manager or engineer keeps abreast of the times and pushes business in quarters hitherto neglected."

The Electro-Deposition of Copper.

THE lengthy letter of Mr. Desmond G. FitzGerald, which appears in our correspondence columns, relieves us of the necessity of replying at length to an esteemed trans-Atlantic contemporary, to whose criticisms we briefly referred in our last number. We would recommend both the New York *Electrical Engineer* and Mr. Stepney Rawson to peruse Mr. FitzGerald's communication, which may tend to make both parties moderate their transports. In connection with this matter we cannot refrain from again mentioning how curiously alike are the contents of Mr. Rawson's recent letter and our contemporary's leader.

SOME FACTS CONCERNING GUTTA-PERCHA.

IN a previous issue (November 21st) we gave a brief description of the conditions attending the gutta-percha industry. The last number (22nd November) of *La Lumière Electrique* contains the first instalment of an article from the pen of M. Sérullas upon the same subject. The author, it appears, is exceptionally well qualified to discuss the question in all its bearings, as not only has he made a special study of the gutta-percha trees, from a botanical point of view, but he was also engaged, between the years 1884 and 1889, in extensive exploration and comprehensive research throughout the gutta-percha producing districts.

The author describes the extirpation of certain varieties of the gutta-percha tree, and explains the difficulty now experienced in obtaining the best gums in any appreciable quantity. He incidentally mentions the fact that two French manufacturing companies were compelled to abstain from competing for cables between France and the north coast of Africa, recently offered to tender by the French Government, owing to the scarcity of gutta-percha of a suitable quality.

M. Sérullas affirms that absolutely no percha, free from adulteration with inferior mixtures, now leaves the forests, and he describes how the natives bring to their villages, for the purpose of general mixing, all sorts and conditions of low-class gums. He further shows that the second-class gums are becoming as scarce as the better variety, and that now the percha quoted as being of the best quality is not even equal to the classes which originally figured as third rate.

Although, the author continues, many European merchants, at the centres of exportation, pride themselves on their intimate knowledge of the attributes of the various gums which come under their notice, they are but children in the hands of the native collectors and of the Chinese middleman. And in addition to the devices and tricks which the gums are subjected to, the difficulties attending the selection of gutta-percha are further increased by the great differences presented by the same species due to the particular locality of growth, the age of the plant, and the method and season of collection. It is consequently impossible to place any reliance upon the supposed quality of gutta-percha, even when carefully selected for employment in its most important *rôle*, that is to say, as the dielectric in submarine cables; the adulteration or mixture of various and inferior gums follows no rule, no proportion, either as to quality, quantity, or species.

M. Sérullas states that after a laboured study of the various gums, he has succeeded in arriving at an analytical method, by which he is able to determine the qualities of mixtures of gums recently collected; but this method cannot be depended upon to indicate the quantities of the component parts, and it is completely at fault with regard to old mixtures. With the latter, chemical reactions, electrical tests, spectral analyses, and microscopical examination, are ineffectual, although in certain cases the presence of secondary resins, and the results of the separation of the glucose colouring matters which stain the gums, may indicate the existence of such and such a gum in the mixture, but that is all.

A gum, such as that obtained from the *Minuesops Balata*, almost entirely composed of the fundamental hydro-carbons of the guttas, is not invariably the one which will be longest in changing. A remarkable fact connected with gutta-percha is that two mixtures, exactly similar in all respects, are quite likely to give very different results after the lapse of a few months. Hence, M. Sérullas says, it is not to be wondered at that different portions of a core, in all of which the same percha is supposed to be used, may develop very dissimilar characteristics, even in a comparatively short period.

Gums of low quality, even when pure, behave with regard to their constancy and lasting properties in the same manner as mixtures. And with respect to oxidation, and to the combination of elements and atomic distribution, a very interesting question presents itself as to the changes in molecular equilibrium to which these substances are subject.

The *Isonandra Gutta*, or *Isonandra Percha*, the most valuable of the family of guttas, is also the one most infrequently met with. It will not grow near the sea, nor at a height of more than 200 feet above the sea level, and, although it requires constant humidity, it does not thrive in the neighbourhood of stagnant water. It is almost exclusively found in shallow ravines where the soil is of a compact clay, and where the roots can seek running water. Other reasons besides those connected with climate and locality combine to make the *Isonandra* scarce. The reproduction of the species by seed never occurs at any considerable distance, the young plants being always found grouped close around the adult trees. The seeds not only very quickly lose their germinative power but when ripe are eagerly sought for by many of the birds and beasts of the forests.

In addition to the wholesale cutting down of adult trees, and of the second growth before it attained maturity, for it has been the practice for some considerable time to cut trees only 10 or 11 years old, the reckless clearing and burning of the forests for the cultivation of gambier, and in Borneo for coffee planting, in Sumatra for coffee growing, and in the Malacca peninsula in the search for tin, have contributed towards the extirpation of the *Isonandra*, for though the jungle grows again after the forests have been burned, the gutta-percha trees do not reappear where fire has once passed.

The serious position in which submarine telegraphy is placed owing to the complete extirpation of the only tree producing a gutta-percha suitable for the core of submarine cables, and the utter failure of all attempts to replace it, for this especial purpose, either by low class gums, or by nondescript preparations, is clearly set forth by M. Sérullas. He points out that all these would be substitutes, are precisely lacking in the very quality which gives its great value to pure gutta-percha of the best variety when used as a dielectric under water, that is to say, its almost indefinite immutability. The author has a good deal to say on this point, but we need not follow him further in this direction, since there is nothing very novel in his remarks, and his contention scarcely admits of controversy.

Some idea may be gained of the tremendous inroads made upon the gutta-percha producing districts of Malaysia from the following figures:—

In 1845 there were imported to Europe 19,836 lbs. of gutta-percha. In 1851 the amount barely reached 30,856 lbs.; but in 1855, when collecting commenced to spread throughout the archipelago, the quantity considerably exceeded 661,200 lbs.

In 1857, there were placed on the Amsterdam market alone nearly 551,000 pounds, which was valued at 3·28 francs per kilogramme, or, roughly, at 1s. 3d. per pound.

In 1870, Malacca and Selangore alone, exported rather more than 220,400 pounds.

In 1879, the quantity imported to Europe reached the enormous total of 4,408,000 pounds; of this amount, Sumatra contributed 297,540 pounds, Borneo 2,865,200 pounds, and the remainder principally came from Padang and Perak.

The gutta-percha brought to the Singapore markets in 1879-80 was double the quantity sold in that place in 1869-70; but since 1880 there has been a considerable and continual decrease. M. Sérullas is not very explicit as to the dates when the various districts despoiled of gutta-percha trees ceased exportation. This information would, perhaps, be difficult to obtain with any degree of accuracy; but we gather that all collecting ceased in Singapore in 1857, in Malacca and Selangore about 1875, and in Perak between 1883 and 1884. These districts, it should be remembered, had been amongst the most fruitful in their yield.

It was not until 1883 that the British Government ordered the cessation of gutta-percha collecting throughout their possessions in the Straits; too late, indeed,

to preserve the existence of the tree. Unfortunately, the method adopted by the natives of collecting the gums attracted but little attention on the part of European Governments until too late to avoid the consequences. The real yield of the gutta-percha tree was unknown until quite recently, and such information as was given, notably, by Dennys, Morton, Von Gaffron, and Schlimmer, led to exaggerated ideas as to the inexhaustible resources of Malaysian forests.

The author, in dealing with the very important question of the yield of sap per tree, points out that even the more moderate estimates of Dr. Burck are greatly in excess of the actuality, and he lays some stress upon the fact that whereas this well-known botanist could only have examined a few trees, and these not under the most favourable conditions, he, M. Sérullas, experimented upon more than 6,000 *Isonandra* of various ages and in different localities.

The *Isonandra* of good quality is not fully grown till 28 or 30 years of age. It then commences to flower, an operation repeated every two years. When mature, the trunk is generally cylindrical, having a circumference of about three feet at a height of 5 feet from the ground. The adult *Isonandra*, under ordinary circumstances, supplies about one-third of a pound of sap. Adopting this figure, M. Sérullas estimates the number of *Isonandra* cut down in Borneo alone during the year 1879 at not much less than five millions.

In attempting to arrive, by reference to the quantity of gum of the best quality exported from Malaysia, at some idea of the destruction of *Isonandra*, it must be remembered that the wholesale cutting of adult trees necessitated, in order to keep up the supply, enormous inroads upon the immature plants, which naturally gave very much less sap per tree than the fully-grown ones.

(*To be continued.*)

ON THE NEW STANDARD EDISON ELECTROLYTIC METER.*

By A. E. KENNELLY and R. S. WHITE.

SINCE the last meeting of the association, the new and improved pattern of the Edison meter has been decided upon, received Mr. Edison's approval, and has been completed by the Edison General Electric Company. It has already been introduced into two stations, Brooklyn and Winnipeg, and the reports upon its behaviour in each case are excellent. There are four standard sizes of these 3-wire meters, Nos. 1, 2, 4 and 8, designed to supply 40, 80, 160 and 320 lamps respectively. Meters of larger capacity than these are made specially. In all sizes, however, the bottles and plates are alike, and of the pattern shown. The spools, too, are alike, making the resistance of the bottle circuit the same in every meter, and the drop of potential in the shunt at full load is the same, namely, four-tenths of a volt.

It is arranged that in the smallest or No. 1 meter, each milligramme of weight transferred represents one ampère-hour of supply, and the transfer is 10 milligrammes per hour on full load. Similarly every meter transfers 10 milligrammes per hour at full load, so that each milligramme of transfer in a No. 8 meter represents eight ampère-hours, and in a No. 4 meter four ampère hours, the number of the meter being the index of the supply in each case.

This greatly simplifies the system, reduces the weight of bottles that have to be daily transported, reduces the stock that the station has to keep in hand, makes only one balance requisite instead of two, and with reasonable care the use of a separate multiplier for each size of meter is not found to be an inconvenience. The objection has been urged against the system that there is danger in making one milligramme of transfer stand for so large a unit as eight ampère-hours in the No. 8 meter, since an error in weighing or in the proportions of the meter would result in an error in the bill eight times as great as the same discrepancies would produce in a No. 1 meter. Even granting the validity of the objection, however, it is evident that since meters are introduced in the capacity proportionate to their duty, the error in the No. 8 meter bill will only bear the same ratio to the whole amount charged, that the smaller No. 1 error bears to its bill. As a matter of experiment, taking, for instance, a series of tests made with the meters by one of the writers at Brooklyn, the records of a set of Nos. 1, 2, 4 and 8 meters, worked in series, and at intervals for a week on half load for the smallest, or five ampères, one-sixteenth of the load for the largest, showed practically the same results, the No. 8 meter under indicating about 2 per cent.

This high degree of relative accuracy, setting aside all questions of care and skill, is secured by three things; The first is a higher degree of absolute accuracy in general. The old pattern meter is universally admitted to be a faithful and accurate instrument, but the intrinsic accuracy of the new pattern is about three times as great. The only chance for error in the operation of the electrolytic meter, accidents aside, is the variation of resistance in the bottle whereby the true ratio between the currents in the bottle and shunt circuits is upset. The extent of such a disturbance of course depends upon the relative proportions of resistance in bottle and spool. Suppose it were possible for the new bottle to even double its resistance and to become 5 ohms instead of 2·5 ohms, at normal temperature. In circuit with a spool of 46½ ohms, such a change would only upset the balance, and make the record in defect 5 per cent. In the old pattern meter the doubling of the bottle resistance, were such a variation to be expected, would make the readings 15 per cent. in defect.

The second preventive of error in the larger sizes is due to the uniformity in the size of plate. A cause of discrepancy has always existed in a slight gain of the plates in weight independently of the current's action and due to their oxidation superficially. With care this source of error has always been minimised, but with the old meters it increased with the size of the meter, since a larger plate offered a larger surface to oxidisation. In the new patterns it is of course a fixed amount in all sizes, and owing to the small area of plate, is in any case very small.

The third precaution against error in the larger sizes is the use of duplicate bottles in the Nos. 4 and 8, as mutual checks which are not required in the Nos. 1 and 2.

Another improvement is in the plates. These are castings of pure zinc alloyed with 2 per cent. by weight of pure mercury. This amalgam has the advantage of being more readily brought into good condition for use than the rolled plate; the trouble of varnishing is also saved.

The only other noteworthy change has been in the solution, which is about twice as dense as in the old bottles.

Mr. Edison has recently completed a mechanical meter on the pattern of one of his early patents in that direction. This instrument is a small motor delicately constructed. The armature commences to rotate as soon as one lamp in the supplied circuit is turned on. The rotation accelerates as more lamps are lit, until at the full load of 20 lamps the speed is 600 revolutions per minute. A counter worked from the armature shaft records the number of rotations, and on duly proportioned dials the supply. The field magnets are kept charged by a feeble current from the mains, while the main current passes through a shunt as in the electrolytic meter, and from the shunt terminals wires pass to the armature. The drop of potential in the shunt at full load is 1·5 volts. The model, though complete in itself, will be slightly modified in detail to suit commercial use, and will then be available for such cases

* Read at the Convention of the Association of Edison Illuminating Companies.

where a mechanical meter is desirable. Mr. Edison does not consider that a mechanical meter can possibly be as cheap or as reliable as the electrolytic meter, firstly, owing to the necessary frictional error which makes the record too low for very light loads and low speeds, and, secondly, owing to the mechanical wear and tear of the working parts, which will need attention and exchange from time to time; but there are cases in which a direct-reading mechanical meter will be an advantage, and he expects that from the tests and behaviour of this model it will serve the purposes.

The conclusions, drawn from an experience of one year with the standard Edison meter, are as follows:—During the year's work with the new standard meter, we have taken 4,088 incandescent, 853 arc lights, and 244 motor readings—a total of 5,185, and have obtained uniformly good results. In a large number of cases customers have kept tally of lamp-hours, and in every instance expressed themselves as satisfied. A considerable number of tests have shown marked accuracy. The greater despatch and care with which the meter work can be performed has been abundantly shown. The use of small and uniform plates secure, by the balance method, doubled accuracy in weighing and the elimination of the oxidisation error. In brief, our experience with the standard meter shows improved ease and economy in operation with more uniform and accurate results. In so far as a chemical meter "fills the bill," little remains to be said.

It may be interesting to note the use of four Aron meters on our circuit for the past year. The frank, open countenances of these meters have won the favour of the meter man and the confidence of the customer. We may conclude, then, it is in the line of a direct reading dial meter that we are to look for the next advance in the commercial treatment of the meter question.

THE ELECTRIC RESISTANCE OF BISMUTH IN A MAGNETIC FIELD.

MONS. A. LEDUC has recently been engaged on the problem of determining a mathematical formula by means of which it would be possible to calculate the resistance

$$R_{M,\,t}$$

of a wire of bismuth placed in a magnetic field of value, M, and at a temperature, $t°$, in terms of its resistance, R_0, at 0°, outside the field.

The resistance at $t°$, outside the field, is well expressed by the general formula

$$R_t = R_0 (1 + k\,t + m\,t^2 + n\,t^3)$$

in which the coefficients vary according to the character of the specimen of bismuth that is being examined.

Under the influence of the field the unit of resistance has been shown to be subject to an augmentation, z, which is given by the hyperbolic equation

$$z^2 + \beta\,z - a\,M^2 = 0.*$$

And this is of such a kind that if we assume $b = \frac{\beta}{2}$ we finally get the formula

$$R_{M,t} = R_0 (1 + k\,t + m\,t^2 + n\,t^3)(1 - b + \sqrt{b^2 + a\,M^2}) \quad (1)$$

Leduc has been examining the influence of temperature upon the coefficients a and b, and at a recent meeting of the Paris Academy of Science he read a paper embodying the results of his research.

The specimens of bismuth which were examined were of the following nature:—One was a fine thread of metal obtained by the electrolysis of the nitrate; the other two were wires wound in the form of a double spiral, and were made from metal that had been fused and run into tubes, which were then placed in an oil bath at 280° C., and slowly cooled down. The metal from which one of these spirals was prepared was the pure bismuth of commerce; in the other case it was specially prepared from the pharmaceutical sub-nitrate by solution in nitric acid, precipitation with ammonia, and subsequent reduction with cyanide of potassium.

On the whole, the results obtained for those specimens were very nearly the same; but the specimen last described had a sensitiveness to magnetism which was superior by 10 per cent. to that of the first, and by about 15 per cent. to that of the second. On the other hand, its resistance outside the field presents a minimum towards 23° C. This specimen was considered by Leduc to be the purest of the three.

The coefficients were both found to vary with the temperature, as indicated in the table below. The influence of temperature diminishes slightly as the intensity of the field increases.

t	18°	44·7°	100°	130·8°	157·5°
$a.\,10^{11}$	221	143	55	33	22
$\beta.\,10^3$	263	275	301	316	342

The values of β are given approximately by the formula

$$\beta = 0{\cdot}258\,(1 + 0{\cdot}000907\,.\,t + 0{\cdot}00000723\,.\,t^2) \quad \ldots\ldots\ldots \quad (2.)$$

Those of $a \times 10^{11}$ are given by the formula

$$a - 10^{11} = 288{\cdot}5\,(1 - 0{\cdot}01455\,.\,t + 808\,.\,10^{-7}\,.\,t^2 - 163\,.\,10^{-9}\,.\,t^3) \quad \ldots\ldots (3.)$$

But this equation indicates at about temperature 165° a change in the curve which experiment does not confirm and according to it a disappears at about 209° C.

Leduc's results are well illustrated by the equation

$$\left.\begin{aligned} a\,.\,10^{11} = 288{\cdot}5\,(1 - 0{\cdot}0145\,.\,t + 819\,.\,10^{7}\,.\,t^2 \\ - 194\,.\,10^{-7}\,.\,t^3 + 141\,.\,10^{-12}\,.\,t^4) \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots \quad (4.)$$

According to this equation a disappears at about 261° C.

In spite of the somewhat empyrical character of this function and the uncertainty existing in the determination of its coefficients, Leduc considers that a does disappear and that the influence of magnetism vanishes at the fusing point of bismuth.

The resistance of a specimen of bismuth may be calculated within the limits of Leduc's experiments by means of the formulae (1), (2) and (3), and probably at temperatures lower than the melting point by means of the formulæ (1), (2) and (4).

It may be added that in the above case we have

$$\begin{aligned} k &= -\ 57.10^{-5} \\ m &= \ \ 125.10^{-7} \\ n &= -\ \ 10^{-9} \end{aligned}$$

In applying this property of bismuth to the measurement of magnetic fields it will be sufficient to know the variations of a and β at the ordinary temperature, and then they may be expressed by the binomial formulæ.

Thus if we express z in thousandths, we may in such an actual case merely take

$$\begin{aligned} a &= 0{\cdot}00231\,[1 - 0{\cdot}0153\,(t - 15)] \\ b &= 131\,[1 + 0{\cdot}0011\,(t - 15)] \end{aligned}$$

And this will only necessitate four measurements of z, made in two known fields, at, for example, 10° and 20° C.

* Vide *Comptes Rendus*. February 1st, 1886, and January 20th, 1890.

Lighting the Meuse Forts.—The War Department in Belgium recently appointed a commission to investigate the subject of employing electric projectors for the defence of the forts of the Meuse. The apparatus, which has been made by the Société de la Meuse, was placed in armoured turrets, which protect the *personnel*, and the current was supplied by a dynamo driven by a gas engine. The report of the commission has not yet been published.

THERMO-ELECTRICAL RESEARCHES.

By MESSRS. CHASSAGNY AND ABRAHAM.*

IN the course of our study of the thermo-electrical elements, the comparison of several couples formed of different metals has furnished us with a valuable means of checking the accuracy of our measurements. This system of check consists in the fact that the values obtained verify very accurately the law of the intermediate metals.

For the known temperatures of the junctions we get, between the electromotive forces of the couples formed by three metals, A, B, C, the relation E (A C) = E (A B) + E (B C).

The experiments were arranged as described in a former article.† In order to ensure the same temperature at the heated junctions, the wires of the metals under consideration were soldered at one end into the same mass of copper. The other extremities, which were soldered to copper wires, were kept in vessels of ice insulated by wedges of paraffin.

The experiments related to couples formed of the following metals:—iron, platinum alloyed with 10 per cent. of rhodium; copper, pure platinum.

We will now give the results of an experiment in which the junction was placed in the vapour of boiling water:—

COUPLES.	Electromotive forces observed. volts.
Iron-platinum alloyed with rhodium	0·0008945
Platinum alloyed with rhodium-copper ...	0·0001980
platinum alloyed with rhodium-platinum ...	0·0007897

From these quantities we deduce for the electromotive forces of the couples iron-copper, iron-platinum, and copper-platinum, the following values, opposite which we have placed those that were observed directly.

Couples.	Electromotive Forces.	
	Calculated.	Observed.
	Volts.	Volts.
Iron-copper	0·0010925	0·0010926
Iron-platinum	0·0016842	0·0016842
Copper-platinum ...	0·0005917	0·0005917

This system of check, which was necessary for the continuation of our researches, shows, at the same time the degree of exactness of the measurements. ‡

THE ELECTRIC LIGHT AND THE PARIS MUNICIPAL COUNCIL.

AT the last meeting of the Paris Municipal Council, it was established that the fire at a café on the boulevard was occasioned by too high electrical tension, and numerous complaints were also expressed as to the large quantity of smoke produced by the plant working the dynamos. A long discussion arose on these two questions raised by MM. Binder and Duplan. The solution, however, as was indicated by M. Lépine, Secretary-General of the Prefecture of Police, did not lie within the jurisdiction of the administration. Still, in order to elucidate the duties of the city authorities in regard to the concessionary companies, the council, on the proposition of M. Ferdinand Duval, invited the Prefect of the Seine, to publish the contracts entered into by the city authorities with the Popp Company for the transmission of power, and with the electric lighting companies. A resolution, proposed and seconded by MM. Stupuy and Morane, was then ordered to be sent to the administration, inviting it to make experiments and trials in order to find a good smoke-consuming apparatus.

We take the following, on the above subject from *Le Soleil*, which it prints under the heading of "The Popp Company":—"The accident which occurred in the cellars of the Grand Café was again spoken of. M. Maurice Binder wished to know the results of the inquiry made by the Prefecture of Police. The Secretary-General of the Prefecture stated that the Popp Company had installed, on its own account, in the cellars of the Grand Café, batteries of accumulators which were used for the feeding of about 1,400 lamps. The accumulators became too highly charged, the apparatus worked badly, which caused an explosion and fire. And it appeared that the same cause had already caused similar effects on several previous occasions, which is the best proof that the surveillance of electrical stations is quite insufficient."

ILLUMINATION BY ARTIFICIAL LIGHTS.

By S. ALFRED VARLEY.

THE report of Sir C. G. Stokes, Lord Rayleigh, and Sir William Thomson, on the respective penetrating powers of oil lights, gas lights, and the electric light through hazy sea atmospheres, has been briefly noticed in the ELECTRICAL REVIEW of October 31st, 1890. The conclusion which was arrived at by the above-named distinguished physicists as the result of carefully-conducted observations is, that the electric light, as exhibited at the South Foreland, has greater penetrating power than the light produced from burning oil or gas.

The purpose of this article is not to criticise in any way the efficiency of the electric light for lighthouse purposes, but to direct attention to certain matters bearing on the subject of general illumination. The object of all artificial illumination is to enable us to see in the absence of sunlight, but the part played by our optical organ seems to the writer to have been very generally overlooked in public discussions on the efficiency of the different systems of artificial illumination.

The amount of light which the earth receives at any given spot is much greater in the summer than in the winter; the light at mid-day is also greater than, say, an hour before sunset; but we nevertheless see practically as well on a bright winter's day as we do in the summer, and we see in the afternoon of a summer's day equally as well as we do at mid-day, the reason being that the pupil of the eye automatically adjusts itself to the amount of light received.

Now, when arc lights are employed for the purpose of general illumination, the brilliancy of the light causes the pupil of the eye to contract, and consequently their actual efficiency is really very much less than that indicated by a photometer.

It would be very interesting if a series of experiments were carried out to determine the penetrating power of quantity, as distinguished from the quality of the light.

The oldest living electrician, as long as he can remember, has been familiar with the terms, quantity, and intensity as applied to electricity, and he has clearly grasped the relationship of the one to the other in electrical phenomena; but the same can scarcely be said of the influence which the quantity of matter in a state of combustion has on the penetrating power of luminous rays through the atmosphere, apart from the actual intensity of the combustion itself.

The penetrating capabilities of a large quantity of burning matter of low intensity were forcibly brought home to the writer in his daily journeys as a schoolboy over Blackfriars Bridge. He was so much impressed with the apparent brilliancy of the lights on the coal-lighters as seen from the bridge on a winter's evening, that he went down to the river bank to ascertain their source, and to his great surprise he found what appeared to be

* *Comptes Rendus de l'Academie des Sciences.*

† Recherches de Thermo-Electricitié (*Comptes Rendus*, Vol. cxi., p. 477, 1890).

‡ Experiments made at the Physics Laboratory of the Higher Ecole Normale.

very brilliant lights when viewed from a distance were only smoky coal fires burning in iron baskets.

The apparent brightness of open coal fires, when viewed from a distance in a dark night, is undoubtedly in no small degree to be attributed to the behaviour of the optical organ itself. The pupil of the eye under such circumstances is very fully dilated, and consequently receives a large pencil of rays, and these rays being of low intensity, they do not irritate the eye and cause the pupil to contract. Now, it is within our experience that a large number of rays of low intensity entering the eye produces a similar effect on the retina, as a smaller number of light rays of higher intensity, and if the fact be taken into consideration that luminous rays of low refrangibility, such as those which a coal fire burning in the open air produces in abundance, are not nearly so much obstructed as rays of light of higher refrangibility (especially when the atmosphere is hazy), then the apparent superior brilliancy to the eye of a coal fire as seen from a distance over that of a gas flame, or even an electric light, is easily accounted for.

The writer well remembers his attention being directed to a very brilliant light in the distance in the middle of a high road, which impressed the eye as being very much more brilliant than the gas lamps, and he found the light proceeded from the turnpike man's fire-grate, an ordinary coal fire, which was not a very brilliant one.

In the year 1860, or thereabouts, a company, actively promoted by the late Sir Charles Bright, was formed for lighting the streets, buildings, &c., with the oxyhydrogen limelight, and the company lighted for a short time, experimentally, old Westminster bridge. So far as general illumination was concerned, the system proved to be a complete failure, the impression produced being that the bridge was dotted with a number of bright and pretty stars, but that the illumination of the bridge was being effected by the ordinary gas lights.

In the year 1874, speaking from memory, the late Robert Sabine, Mr. Gatehouse, and the writer were experimenting at the British Telegraph Company's works with a Gramme machine of the—at that time—largest size manufactured. The electric lamp was in a glass room on the top of the building looking towards the south, and the day was fine, but the sky was covered with light clouds through which the sun shone.

We had a long wedge of semi-opaque neutral tinted glass for looking at the arc with, the surfaces of the wedge were ground flat and polished, the thinner end being a knife-edge and the thicker end being about half-an-inch thick. When looking through the wedge at about two inches from the thinner end the electric light was just visible to the eye, and a little higher up it became wholly obscured. Now the writer found to his surprise that when he looked at the sun through this wedge the sun could be seen through a considerably greater thickness of the semi-opaque glass than the electric light was capable of penetrating. It occurred to him afterwards that the wedge was possibly largely composed of opaque matter, and that the light passed through what was practically a number of fine pin holes, and that, as when looking at the arc, the glass wedge was not more than 7 or 8 inches from it, the greater percentage of the rays struck the glass at an angle and passed consequently through a greater thickness than they would have done if the rays had been parallel as was the case when looking at the sun. At the same time, it seems somewhat remarkable that the sun's rays after passing through 95,000,000 miles of space, and then through clouds and our atmosphere, should have greater power to penetrate semi-opaque matter than an electric arc light which was only a few inches from the glass wedge.

Everyone who has witnessed a great fire must have been impressed with its powers to illuminate. The writer had the good fortune to see the great fire which occurred in Tooley Street, now, a good many years ago. The dome of St. Paul's, the Monument, and the buildings on the Middlesex side of the river were lighted up magnificently, owing to the quantity of light as distinguished from the intensity of the combustion.

Now the writer would very much like to see systematic experiments carried out to ascertain the respective penetrating powers of coal fires, gas lights, and the electric light through hazy atmospheres, and he would not be surprised if the results obtained from such experiments went to show that, under special conditions, it would be more economical for the purpose of illuminating distant objects, for a given amount of coal to be burned in an open fire grate than to burn a similar quantity in a steam engine, and from the energy developed, produce an electric light.

ELECTRICITY METERS.*

By ROBERT SHAND.

BEFORE proceeding to consider the subject of this paper, it may be interesting to glance briefly at the developments which have secured for electricity meters the wide attention they receive, and which have made them important factors in the success of any general system of electrical distribution.

When the incandescent lamp was first introduced to an expectant public, people were quick to recognise its many merits and advantages, and the more consideration they gave the new illuminant, the more apparent became its vast superiority to all other illuminants in use for purposes of interior illumination. It was cleanly, and produced comparatively little heat, the atmosphere was not robbed of oxygen and vitiated with combustion products, as was the case where gas or oil flames were employed, and it could be used in many places where gas or oil would be unsafe. It was perfectly understood, however, by those interested in the development of the new illuminant, that however much it might be admired, however desirable it might appear, its progress into general use would be determined principally by its price. If it cost more than people were accustomed to pay for their light, they would continue the use of the elderly, smoky article, and await the development—that is, the cheapening of the new and cleanly method of lighting. The expense and difficulty attendant on the maintenance of small isolated installations, involving the use of steam, gas, or other engines, dynamos, &c., was such as but few people could afford to incur; so that as long as this presented the only means whereby the benefits of the new illuminant could be secured, it must remain a luxury, the desired development could not be effected, and its progress into use must necessarily be extremely slow and unsatisfactory.

Consideration, then, of the practical requirements for the supply of small consumers, suggested the construction of central stations where electric energy could be generated on a large scale, and which could be fitted with a wide-spreading system of conductors in such a manner, that people so desiring, could have stores, houses, &c., within the area of distribution fitted up, and electric energy placed at their disposal in a manner analogous to that followed by gas and water companies in their supply systems. The construction of central stations promised cheap distribution, and as, at that time, cheap production of electric energy by means of dynamo-electric machines was already an accomplished fact, it was assumed quite generally that electrical energy would almost immediately become available to small consumers; but unfortunately many obstacles, then unforseen, acted to postpone the realisation of these sanguine hopes.

Towards the end of the year 1886 it was estimated that the total number of incandescent lamps in use in the United States was only about one-half million, all practically supplied on the two and three-wire, low tension, direct system. Then came the development of the high tension parallel system of distribution employing alternating currents and transformers. Many local companies engaged in arc lighting saw the opportunity afforded them to supply incandescent lamps also, and quickly took their places in the new field of

* New York *Electrical World*.

enterprise thus opened. They realised that by using this transformer system many of the obstacles that prevented the growth of incandescent lighting on the low tension direct system, in other than districts closely built, were materially reduced. Numerous new companies were organised that made more or less a speciality of the alternating current system. Their activity reacted on those engaged in the development of direct current supply systems, spurring them to renewed and greater efforts than before, with the result that at the present time a conservative estimate places the number of incandescent lamps in use in the United States at over three millions, of which number probably one-third are supplied on the alternating current system. This development still continues, and its progress is so rapid that one cannot be said to risk much in expressing the belief that we are now on the highway toward the realisation of the condition of things eagerly anticipated and hoped for when central station construction was commenced; that is, a distribution of electric energy so cheap and so generally available that all who wish may become consumers and secure its benefits, the one necessary condition being that they agree to pay the exact value of the energy consumed, no more, no less.

This brings us at once to the question, On what depends the value of the electric energy consumed? This question must be answered before we can begin to devise methods of determining the "value received" which it is necessary to know before presenting the consumer with the record of his extravagance—his bill.

The value of the supply depends upon its volume or quantity and the electromotive force or pressure at which it is delivered. The product of the current in ampères by the electromotive force in volts gives the rate of the supply, that is, the power at any time in volt ampères, or watts. The total consumption, therefore, is represented by the product,

$$\text{volts} \times \text{ampères} \times \text{time}$$
$$\text{or volts} \times \text{coulombs.}$$

For example: if we suppose two incandescent lamps in use, each taking one ampère of current at 50 volts potential, electric energy is then being converted into heat in the lamps at the rate of 100 watts per second. Assuming the current and the pressure to remain constant for one hour, the energy converted into heat in the lamps during that hour will equal 100 watts for 3,600 seconds, or 360,000 watt seconds or joules. In practice this quantity would probably be expressed at 100 watt hours. It might also be expressed as 265,000 foot-pounds, or ·134 horse-power hours. When an ampère hour is spoken of, the electromotive force or pressure is disregarded, and an expression adopted which it is sometimes convenient to use, what is really meant being a supply of 3,600 coulombs of quantity of electricity. This supply may be delivered in a second, or in an hour, or any measurable interval of time may be taken in its delivery, but so long as the product of the current strength in ampères by the time during which it was supplied equals 3,600, it may be expressed as an ampère hour.

For the measurement of any particular time of the electrical quantities we are considering, numerous beautiful and accurate instruments are available, but these evidently cannot comply with the conditions for ascertaining the value of a supply, extending, it may be, over a month or longer, the reason of this being that they are not furnished with means of constant following and registering its successive progressions. In order to know the value of a consumer's supply with certainty and completeness, an instrument must be provided capable of measuring the two factors of the supply—quantity and pressure—and also capable of making a continuous and cumulative record of the supply as it proceeds. An instrument capable of doing this is called a watt-hour meter, energy meter, or erg meter. When, however, it is considered permissible that the pressure factor be accepted as a constant by which the ampère seconds or coulombs recorded may be multiplied and the product accepted as representing the energy consumed, then the instruments capable of doing this, of recording ampère seconds or coulombs, are called coulomb meters.

In any parallel system of supply the maintenance of constant potential at all points of supply is the characteristic and most important feature, and, where it is maintained, coulomb meters may do the work satisfactorily, but where the potential fluctuates between limits not necessarily wide, energy meters would appear to be desirable.

In forming an opinion regarding the relative merits of coulomb and energy meters, it must be remembered that what the consumer pays for is energy, and if the potential factor of his supply is allowed to fall, the result will probably be a much greater fall in the efficiency of his supply, whether light or power called for at the point of consumption. It would certainly appear, therefore, that the most scientific instrument, the energy meter, ought also to be the most satisfactory in use, inasmuch as it most nearly measures that which the consumer really pays for. If electrical energy was a material substance, a rarefied combustible, for instance, like its would-be rival, gas, it would then be sufficient that the coulomb-meter measure its volume, temperature and pressure being constant, in order to know the amount of consumption. Electricity, however, cannot be measured by the cubic foot like gas, and since it cannot be measured directly at all, some of the effects produced in the conductor, or in the neighbourhood of the conductor, must be measured; in other words, it must be made to do work of some kind, and the relation existing between the amount of work done and the electric energy necessary to do it having been determined, the one becomes the measure of the other.

The effects, then, which electricity is capable of producing are three in number, viz., chemical, magnetic, and heating, and these three effects or properties mark three lines along which inventors have laboured in the production of electricity meters.

The first of these properties, the chemical, has been extensively applied ever since its laws were discovered by Faraday. When a current of electricity passes through an electrolytic cell containing the salt of a metal in solution, it carries metal with it to the cathode (*i.e.*, the plate by which it leaves the liquid), and deposits it there. The weight of metal thus deposited is proportional to the number of coulombs that have passed through the cell, and, in order to determine the number, it is sufficient that one of the plates be removed from the cell, weighed, and the difference in weight, the amount it has gained or lost, divided by the number representing the weight of metal which an ampère in a second would deposit from the solution contained in the cell.

This method is so beautifully simple, and so easily applied in any direct system of supply, that a superficial view would suggest its immediate adoption. If we study the method closely, however, with the view of applying it to our purpose, we find in the electrolytic cell inherent weaknesses which are apt to become quite important sources of error when the cell is left to itself for any considerable length of time. Non-uniformity in density of solution employed, foreign substances present in the material of the plates, variations of temperature, are some of the causes interfering with the reliability of the method. If we consider, also, that the consumer is unable to inform himself regarding the progress of his supply by inspecting his meter, and the necessity which exists for taking the meter apart in order to discover it, we will probably concede the possession by the electrolytic cell of many features undesirable in a meter.

The magnetic property of the electric current is apparently the one of which the greatest number of inventors have availed themselves, and which they have applied in the construction of meters. Often, when this method is applied, the meter takes the form of an electric motor having a revolving armature and fitted with some brake device which absorbs the work of the

motor in such a way as to make its rate of movement proportional to the current strength. For example, if the force acting on the armature is proportional to the square of the current, in order that the motor may rotate with twice the velocity when the strength of the current is doubled, it is necessary that the square of the rotations measure the brake force against which the motor is doing work; then the square of the number of rotations in a given time is a measure of the square of the electric current. Therefore, the rate of rotation measures the strength of the current and the number of rotations its quantity.

A form of electric motor, in the adaptation of which to use as an electricity meter, much thought and labour has been expended by inventors, is that depending for its action on the electro-magnetic rotation of mercury. When mercury (or other conductor) is traversed by radial currents (*i.e.*, currents which enter at the centre and leave at the outside, or *vice versâ*) and is at the same time acted upon by a magnetic field, the lines of induction in which act in a direction perpendicular to the surface of the mercury, it will rotate in a direction perpendicular to the lines of force and to the direction of flow of the current. Reversing the field changes the direction of rotation, but if at the same time the direction of flow of the current be changed, the direction of rotation will remain as before. The rotative force is said to vary as the square of the current, and the speed as the square root of rotative force. Liquid friction, therefore, in this case supplies the necessary controlling force. We see, therefore, that such a meter should be applicable to both systems of supply. With one notable exception, however (which will be mentioned later), inventors would seem to have met but scant measure of success in the adaptation of this form of motor meter.

In another application the meter takes the form of a machine driven by a constant force and controlled by a force which is also constant so long as no current passes through the conductor. Immediately when the current passes, however, the controlling force is modified, and the velocity of the machine accelerated by a quantity determined by and proportional to the rate of consumption. The acceleration thus becomes a measure of the consumption.

The heating effect of the electric current has received much attention, and many applications have been made of it to the work of electricity meterage since alternating current supply systems became prominent. When a current of electricity passes through a conductor, resistance is encountered and heat is generated, as shown by Joule, at a rate represented by the resistance multiplied by the square of the current. The heating effect being practically the same with alternating and with direct currents, its application seemed to promise a meter equally applicable in both systems of supply, which would approach the electrolytic method in its simplicity, and share at least one important advantage of the magnetic method, inasmuch as it might readily be made to register on dials. Numerous novel and beautiful applications of the heating property of an electric current have been made by Prof. Elihu Thomson to meters, giving their indications by the expansion of gases, by the evaporation, under special conditions, of various liquids, and in other ways.

The ordinary compound bar formed from two strips of material, generally metals possessing different coefficients of expansion and firmly attached to each other throughout their length, may also, in certain combinations, be applied to metering purposes. If one end of such a bar be fixed, and the other end left free to move under the influence of heat, the free end will be deflected through a distance which will be greater or less according as the heat producing the deflection is greater or less. If an inking stylus be attached to the free end of such a bar, and a cylinder or circular dial carrying a properly lined chart revolved at a constant speed in such relation to the bar that the stylus bears lightly against the surface of the chart, heat developed in the bar will cause it to be deflected and the stylus will trace a line on the chart at a greater or less distance from the zero point, according as the flow of current heating the bar is greater or less. It is apparent, however, that an ordinary compound bar being a simple temperature-measuring device will have motions of its own, independent of the current effect, produced by variations of temperature in the surrounding atmosphere. Errors due to this cause must be avoided. Profs. Geyer and Bristol, in a meter invented by them and constructed on the above plan, avoid this source of error by substituting for the common bar its equivalent made from two pieces of the same material, to one of which is given a radiating surface very much greater than that possessed by the other one. These pieces are firmly secured together, but insulated from each other throughout the greater portion of their length, and are traversed in series by the current which it is desired to measure.

The meter of Prof. E. W. Rice is an integrating or recording meter, and in its construction the arrangement of the compound bars at once eliminates all danger of errors arising from changes of external temperature. In its arrangement two bars are used, which are secured a short distance apart, their free ends being yoked together. The construction of the bars is such that a very slight development of heat is sufficient to effect a considerable displacement of the free ends. Heat is developed in the bars alternately, one only being in the circuit at any time. A slow vibration of the bars results, and within certain limits the rate of vibration can be made to measure to a close approximation the rate of flow of current, which is registered on a common counter in the usual manner.

Another method is that applied by Prof. Forbes. The current to be measured is passed through a conductor placed under a glass or metal cover. When the conductor becomes heated, connection currents circulate in the air in which the conductor is immersed, and these currents are made to expend a portion of their energy in driving a mechanism which effects the registry.

We will now briefly consider a few of the meters which have met with more or less extensive application in practical work. A meter which has been much noticed of late is that known as the Aron meter. This meter is a development of the clock ergmeter proposed by Profs. Ayrton and Perry many years ago. Its operation depends on the fact that, within certain limits, the rate of vibration of a pendulum increases with the square roots of the forces attracting it. In one form of this instrument a permanent steel magnet forms the pendulum bob, and immediately underneath, secured to the base of the instrument, is placed a coil of wire, through which the whole of the current to be measured is passed. In the meter case are placed two clock movements; one drives an ordinary pendulum, the other drives the pendulum carrying the magnet; the acceleration of the latter, due to increase of the attracting force acting on the magnet when current is passing in the coil is, by means of differential gearing connecting the two clock movements, indicated upon dials, which are read by the aid of a constant experimentally determined for each instrument. This arrangement constitutes a coulomb meter.

The arrangement originally proposed by Profs. Ayrton and Perry (who seem quite early to have recognised the importance of the meter question) was that of an energy meter, the pendulum bob being a fine wire coil of high resistance connected in shunt across the installation. The latest form of the Aron meter, one which is applicable to the meterage of both alternating and direct systems of supply, is constructed according to their method, the bob being a coil of thin wire attached to the end of the pendulum rod and encircled by the horizontally placed current coil. An interesting feature of this meter is the differential gearing. Two wheels, each about one and a quarter inches in diameter, and having two sets of teeth, being at once spur wheels and crown wheels, are placed about half an inch apart and driven in opposite directions on the same axis, one by each of the clocks. The cylindrical (or crown) gears are placed opposite each other, and a small planet wheel, free at the same time to turn on its own axis

and to roll around that of the cylindrical gears, is arranged between the latter, engaging both. Evidently if the velocity of the two wheels is equal and opposite, the planet wheel will simply be turned on its own centre, but if one of the wheels be driven at a greater velocity than the other, then the planet wheel will suffer a displacement, and will be carried round bodily in the direction and rotation of the wheel having the greater velocity, and this displacement being recorded indicates the consumption. When carefully placed in position, and delicately adjusted, this meter operates satisfactorily, and is sufficiently accurate. It is, however, large, and as yet costly, and it also requires that the clock springs be wound up about once a month.

The meter constructed by Prof. Forbes and introduced by him some two years ago is a beautiful instrument, sufficiently economical and capable of metering alternating and direct currents with equal accuracy. It would, therefore, seem to possess the qualities necessary to secure it a wide application in practical work. It does not appear, however, to have been applied to any extent in the United States. This meter depends for its action on the air currents created by the heat developed in a spirally arranged conductor attached to the base of the instrument; the resistance is said to be about one-hundreth of an ohm. Pivoted above this conductor is a light paper cone having a small pinion attached at the apex and a ring of thin mica at the base. Around the periphery of this ring are fixed eight small cylinders of pith, each carrying a light mica vane inclined at an angle of about 45 degrees to the mica ring. Inside the pinion at the top is a ruby jewel, which rests on a needle point supported upon and rising from the base of the instrument. When current passes through the conductor the convection currents rising impinge on the vanes and cause the cone to revolve (at a rate which Prof. Forbes succeeded in making almost exactly proportional to the current passing through the conductor) and to drive the counter which registers the number of revolutions. The revolving part of this meter is exceedingly light, and when the recording train is carefully constructed, the friction, it is claimed, is relatively small, even when the current is only one-twentieth of the meter's rated capacity. This instrument, is, of course, a quantity or coulomb meter.

The meter of Mr. Shallenberger is essentially an alternating current quantity, or coulomb meter. The construction of the meter is about as follows:

A coil of copper wire of oblong shape, placed horizontally, and traversed by the whole of the current to be measured, constitutes what may be called a primary or inducing circuit. Secured in the interior of this coil are a number of bare copper punchings, which, together, form a closed secondary circuit, and become the seat of induced currents. The planes of the primary and secondary coils cross each other at an angle of about 45 degrees. Inside the secondary closed coil, and closely embraced by it, is a thin ring of soft iron, secured on a light steel shaft, which is pivoted vertically, and free to rotate. The pulses of current, alternating in direction, and flowing through the outer coil to the lamps, induce secondary currents in the closed conductor, and also at the same time polarise the iron ring. Assuming these poles to be formed along the magnetic axis of the coil creating them, they will immediately be attracted toward the field of the closed secondary circuit, situated at an angular distance of about 45 degrees. Thus the pivoted iron being free to rotate, a motive force is created, which is within the range of the instrument approximately proportional to the square of the current. The controlling force in this meter is afforded by air friction, which opposes the motion of a four-winged fan, secured to the shaft carrying the iron ring. It is evident the indications of this meter must be affected by barometric and temperature changes, and also, to some small degree, by changes in the rate of alternations. The former effect would probably be specially noticeable if meters calibrated at sea level were used at varying heights above sea level. These meters are made of 20 and 40 ampère capacity, and a large number are said to be in use.

The meter of Mr. Ferranti, though almost unknown in the United States, is said to be extensively employed in England in connection with the supply system of that inventor. This is a kind of motor meter, having a magnetic circuit which suggests that of Dr. Hopkinson's Manchester dynamo, the top pole piece, however, being prolonged downward, and wound with a few turns of copper conductor, around which the current is led to the mercury, which it traverses radially. The mercury being placed in a gap in the magnetic circuit, and crossed by lines of force, rotates, carrying a small paddle around with it. A small pinion fixed on a slender shaft rising from the paddle, drives a carefully jewelled train of wheel-work which registers the revolutions. Long range is one of the points aimed at in this meter, and the iron used in its construction (which is laminated) being necessarily but slightly magnetised, the driving force developed by small currents is feeble, thus making the internal friction of the machine relatively important.

Prof. Elihu Thomson early realised the importance assumed by internal friction in meters dynamical in their action, and devised a method by which errors due to it could be made vanishingly small without making extreme delicacy of construction necessary; this he accomplished by supplying to the meter subsidiary energy by means of a shunt or special winding, for instance, sufficient to create a force equal to that opposed by friction and inertia. Since that time the method has been applied by others. Mr. Ferranti winds on his meter magnet a high resistance shunt coil in addition to the conductor carrying the current measured. Arranged in this way a 50-ampère meter is said to start with less than one ampère, a range and a delicacy which are certainly remarkable in an instrument of its class.

An exceedingly interesting application of the electrolytic method to the metering of alternating currents has been made by the English firm of Lowrie, Hall and Co. In applying their method the inventors include in the secondary circuit of the transformer an electrolytic cell containing a saturated solution of copper sulphate in distilled water. The copper plates employed in the cell expose a surface of four square inches per ampère with maximum load. In the same box with the deposition cell is placed an accumulator cell, and the entire current supplied to the lamps is passed through these two cells in series. The effect of this arrangement is to introduce an electromotive force of constant direction into the circuit which adds itself to the alternating electromotive force during the half period when it is in the same direction, and subtracts itself during the half period when it is in the opposite direction. If, for instance, the alternating electromotive force equals 100 volts, and the constant electromotive force of the accumulator cell is two volts, then in the one direction there is acting an electromotive force of 102 volts, and in the other direction, an electromotive force of 98 volts. The volume of current, therefore, flowing in one direction during a half period is greater than that flowing during the other half period by a quantity equal to four volts divided by a resistance which is determined by the number of lamps in circuit. This quantity of current is available, therefore, to make a record in an electrolytic cell. This system does not suggest itself as a very practical one, but is, however, exceedingly interesting from the fact of its being the only application of the electrolytic method to the commercial meterage of alternating currents.

In this article it has merely been attempted to describe a few types of meter in common use. A very large number, however, have been invented and from time to time introduced. Reference, however, to the work of each inventor is more than can be attempted in any single article on the subject. And still the work goes on, no existing electricity meter satisfying all requirements so fully as to render its use completely satisfactory.

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

(*Continued from page 650.*)

ELECTRO-MAGNETS FOR MAXIMUM TRACTION.

These have already been dealt with in the preceding lecture; the characteristic feature of all the forms suitable for traction being the compact magnetic circuit.

Several times it has been proposed to increase the power of electro-magnets by constructing them with intermediate masses of iron between the central core and the outside, between the layers of windings. All these constructions are founded on fallacies. Such iron is far better placed either right inside the coils or right outside them, so that it may properly constitute a part of the magnetic circuit. The constructions known as Camacho's and Cance's, and one patented by Mr. S. A. Varley in 1877, belonging to this delusive order of ideas, are now entirely obsolete.

Another construction which is periodically brought forward as a novelty is the use of iron windings of wire or strip in place of copper winding. The lower electric conductivity of iron, as compared with copper, makes such a construction wasteful of exciting power. To apply equal magnetising power by means of an iron coil implies the expenditure of about six times as many watts as need be expended if the coil is of copper.

ELECTRO-MAGNETS FOR MAXIMUM RANGE OF ATTRACTION.

We have already laid down the principle which will enable us to design electro-magnets to act at a distance. We want our magnet to project, as it were, its force across the greatest length of air gap. Clearly, then, such a magnet must have a very large magnetising power, with many ampère turns upon it, to be able to make the required number of magnetic lines pass across the air resistance. Also it is clear that the poles must not be too close together for its work, otherwise the magnetic lines at one pole will be likely to curl round and take short cuts to the other pole. There must be a wider width between the poles than is desirable in electro-magnets for traction.

ELECTRO-MAGNETS OF MINIMUM WEIGHT.

In designing an apparatus to put on board a boat or a balloon, where weight is a consideration of primary importance, there is again a difference. There are three things that come into play—iron, copper, and electric current. The current weighs nothing, therefore if you are going to sacrifice everything else to weight, you may have comparatively little iron, but you must have enough copper to be able to carry the electric current; and under such circumstances you must not mind heating your wires nearly red hot to pass the biggest possible current. Provide as little copper as you conveniently can, sacrificing economy in that case to the attainment of your object; but of course you must use fire-proof material, such as asbestos, for insulating, instead of cotton or silk.

A USEFUL GUIDING PRINCIPLE.

In all cases of design there is one leading principle which will be found of great assistance, namely, that a magnet always tends so to act as though it tried to diminish the length of its magnetic circuit. It tries to grow more compact. This is the reverse of that which holds good with an electric current. The electric circuit always tries to enlarge itself, so as to enclose as much space as possible, but the magnetic circuit always tries to make itself as compact as possible. Armatures are drawn in, as near as can be, to close up the magnetic circuit. Many two-pole electro-magnets show a tendency to bend together when the current is turned on. One form in particular, which was devised by Ruhmkorff for the purpose of repeating Faraday's celebrated experiment on the magnetic rotation of polarized light, is liable to this defect. Indeed, this form of electro-magnet is often designed very badly, the yoke being too thin, both mechanically and magnetically, for the purpose which it has to fulfil.

Here is a small electric bell, constructed by Wagener of Wiesbaden, the construction of which illustrates this principle. The electro-magnet, a horseshoe, lies horizontally; its poles are provided with protruding curved pins of brass. Through the armature are drilled two holes, so that it can be hung upon the two brass pins; and when so hung up it touches the ends of the iron cores just at edge, being held from more perfect contact by a spring. There is no complete gap, therefore, in the magnetic circuit. When the current comes and applies a magnetizing power it finds the magnetic circuit already complete in the sense that there are no absolute gaps. But the circuit can be bettered by tilting the armature to bring it flat against the polar ends, that being indeed the mode of motion. This is a most reliable and sensitive pattern of bell.

Electro-magnetic Pop-gun.—Here is another curious illustration of the tendency to complete the magnetic circuit. Here is a tubular electro-magnet (fig. 53), consisting of a small bobbin, the core of which is an iron tube about two inches long. There is nothing very unusual about it; it will stick on, as you see, to pieces of iron when the current is turned on. It clearly is an ordinary electro-magnet in that respect. Now suppose I take a little round rod of iron, about an inch long, and put it into the end of the tube, what will happen when I turn on my current? In this apparatus as it stands, the magnetic circuit consists of a short length of iron, and then all the rest is air. The magnetic circuit will try to complete itself, not by shortening the iron, but by *lengthening* it; by pushing the piece of iron out so as to afford more surface for leakage. That is exactly what happens; for, as you see, when I turn on the current the little piece of iron shoots out and drops down. You see that little piece of iron shoot out with considerable force. It becomes a sort of magnetic pop-gun. This is an experiment which has been twice discovered. I found it first described by Count Du Moncel, in the pages of *La Lumière Electrique*, under the name of the "pistolet électromagnétique;" and Mr. Shelford Bidwell invented it independently. I am indebted to him for the use of this apparatus. He gave an account of it to the Physical Society, in 1885, but the reporter missed it I suppose, as there is no record in the Society's proceedings.

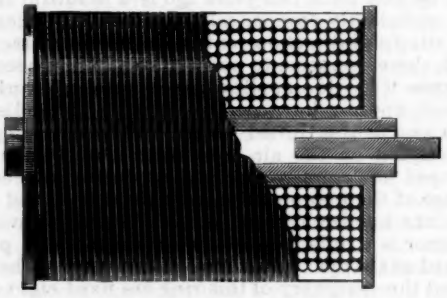

FIG. 53.—ELECTRO-MAGNETIC POP-GUN.

ELECTRO-MAGNETS FOR USE WITH ALTERNATING CURRENTS.

When you are designing electro-magnets for use with alternating currents, it is necessary to make a change in one respect, namely, you must so laminate the iron that internally eddy currents shall not occur; indeed, for all rapid acting electro-magnetic apparatus it is a good rule that the iron must not be solid. It is not usual with telegraphic instruments to laminate them by making up the core of bundles of iron plates or wires, but they are often made with tubular cores, that is to say, the cylindrical iron core is drilled with a hole down the middle, and the tube so formed is slit with a saw-cut to prevent the circulation of currents in the stance of the tube. Now when electro-magnets are to be employed with rapidly alternating currents, such as are used for electric lighting, the frequency of the alternations being usually about 100 periods per second, slitting the cores is insufficient to guard against eddy-cerrents; nothing short of completely laminating the cores is a satisfactory remedy. I have here, thanks to the Brush Electric Engineering Company, an electro-magnet of the special form that is used in the Brush arc lamp when required for the purpose of working in an alternating current circuit. It has two bobbins that are screwed up against the top of an iron box at the head of the lamp. The iron slab serves as a kind of yoke to carry the magnetism across the top. There are no fixed cores in the bobbins, which are entered by the ends of a pair of yoked plungers. Now in the ordinary brush lamp for use with a steady current, the plungers are simply two round pieces of iron tapped into a common yoke; but for alternate current working this construction must not be used, and instead a U-shaped double plunger is used, made up of laminated iron, riveted together. Of course it is no novelty to use a laminated core; that device, first used by Joule, and then by Cowper, has been re-patented rather too often during the past fifty years to be considered as a recent invention.

The alternate rapid reversals of the magnetism in the magnetic field of an electro-magnet, when excited by alternating electric currents, sets up eddy-currents in every piece of undivided metal within range. All frames, bobbin tubes, bobbin ends, and the like, must be most carefully slit, otherwise they will overheat. If a domestic flat-iron is placed on the top of the poles of a properly laminated electro-magnet, supplied with alternating currents, the flat-iron is speedily heated up by the eddy-currents that are generated internally within it. The eddy-currents set up by induction in neighbouring masses of metal, especially in good conducting metals such as copper, give rise to many curious phenomena. For example, a copper disc or copper ring placed over the pole of a straight electro-magnet so excited is violently repelled. These remarkable phenomena have been recently investigated by Professor Elihu Thomson, with whose beautiful and elaborate researches we have lately been made conversant in the pages of the technical journals. He rightly attributes many of the repulsion phenomena to the lag in phase of the alternating currents thus induced in the conducting metal. The electro-magnetic inertia, or self-inductive property of the electric circuit, causes the currents to rise and fall later in time than the electromotive forces by which they are occasioned. In all such cases the impedance which the circuit offers is made up of two things—resistance and inductance. Both these causes tend to diminish the amount of current that flows, and the inductance also tends to delay the flow.

* Cantor Lecture. Delivered before the Society of Arts, February 3rd, 1890.

Electro-Magnets for Quickest Action.

I have already mentioned Hughes's researches on the form of electro-magnet best adapted for rapid signalling. I have also incidentally mentioned the fact that where rapidly varying currents are employed, the strength of the electric current that a given battery can yield is determined not so much by the resistance of the electric circuit, as by its electric inertia. It is not a very easy task to explain precisely what happens to an electric circuit when the current is turned on suddenly. The current does not suddenly rise to its full value, being retarded by inertia. The ordinary law of Ohm in its simple form no longer applies; one needs to apply that other law which bears the name of the law of Helmholtz, the use of which is to give us an expression, not for the final value of the current, but for its value at any short time, t, after the current has been turned on. The strength of the current after a lapse of a short time, t, cannot be calculated by the simple process of taking the electromotive force and dividing it by the resistance, as you would calculate steady currents.

In symbols, Helmholtz's law is:—

$$i_t = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right).$$

In this formula i_t means the strength of the current after the lapse of a short time t; E is the electromotive force; R the resistance of the whole circuit; L its co-efficient of self-induction; and e the number 2·7183, which is the base of the Napierian logarithms. Let us look at this formula; in its general form it resembles Ohm's law, but with a new factor, namely, the expression contained within the brackets. This factor is necessarily a fractional quantity. for it consists of unity less a certain negative exponential, which we will presently further consider. If the factor within brackets is a quantity less than unity, that signifies that i_t will be less than E ÷ R. Now the exponential of negative sign, and with negative fractional index, is rather a troublesome thing to deal with in a popular lecture. Our best way is to calculate some values, and then plot it out as a curve. When once you have got it into the form of a curve, you can begin to think about it, for the curve gives you a mental picture of the facts that the long formula expresses in the abstract. Accordingly we will take the following case. Let E = 2 volts; R = 1 ohm; and let us take a relatively large self-induction, so as to exaggerate the effect; say let L = 10 quads. This gives us the following:—

t (sec.)	$e^{+\frac{R}{L}t}$	i_t
0	1	0
1	1·105	0·950
2	1·221	1·810
5	1·649	3·936
10	2·718	6 343
20	7·389	8·646
30	20 08	9 501
60	403 4	9·975
120	162800·0	9 999

In this case the value of the steady current, as calculated by Ohm's law, is 10 ampères; but Helmholtz's law shows us that with the great self-induction, which we have assumed to be present, the current, even at the end of 30 seconds, has only risen up to within 5 per cent. of its final value; and only at the end of two minutes has practically attained full strength. These values are set out [in the highest curve in fig. 54, in which, however, the

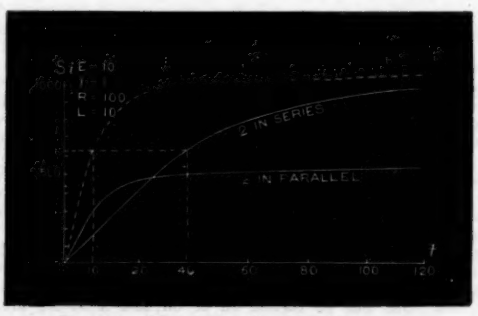

Fig. 54.—Curves of Rise of Currents.

further supposition is made that the number of spirals, S, in the coils of the electro-magnet is 100, so that when the current attains its full value of 10 ampères, the full magnetising power will be S i = 1,000. It will be noticed that the curve rises from zero at first steeply and nearly in a straight line, then bends over, and then becomes nearly straight again, as it gradually rises to its limiting value. The first part of the curve—that relating to the strength of the current after *very small* interval or time—is the period within which the strength of the current is governed by inertia (*i.e.*, the self-induction) rather than by resistance. In reality the current is not governed either by the self-induction or by the resistance alone, but by the ratio of the two. This ratio is sometimes called the "time constant" of the circuit, for it represents *the time* which the current takes in that circuit to rise to a definite fraction of its final value. This definite fraction is the fraction $\frac{e-1}{e}$; or in decimals, 0·634. All curves of rise of current are alike in general shape—they differ only in scale; that is to say, they differ only in the height to which they will ultimately rise, and in the time they will take to attain this fraction of their final value.

Example (1).—Suppose E = 10; R = 200 ohms; L = 8. The final value of the current will be 0·025 amp. or 25 milliampères. Then the time constant will be 8 ÷ 400 = $\frac{1}{50}$th sec.

Example (2).—The P.O. Standard "A" relay has R = 400 ohms; L = 3·25. It works with 0 5 milliampère current, and therefore will work with 5 Daniell cells through a line of 9,600 ohms. Under these circumstances the time constant of the instrument on short circuit is 0 0081 sec.

It will be noted that the time constant of a circuit can be reduced either by diminishing the self-induction or by increasing the resistance. In fig. 54 the position of the time constant for the top curve is shown by the vertical dotted line at 10 seconds. The current will take 10 seconds to rise to 0·634 of its final value. This retardation of the rise of current is simply due to the presence of coils and electro-magnets in the circuit; the current as it grows being retarded because it has to create magnetic fields in these coils, and so sets up opposing electromotive forces that prevent it from growing all at once to its full strength. Many electricians, unacquainted with Helmholtz's law, have been in the habit of accounting for this by saying that there is a lag in the iron of the electro-magnet cores. They tell you that an iron core cannot be magnetised suddenly; that it takes time to acquire its magnetism. They think it is one of the properties of iron. But we know that the only true time lag in the magnetisation of iron—that which is properly termed "viscous hysteresis"—does not amount to any great percentage of the whole amount of magnetisation, takes comparatively a long time to show itself, and cannot therefore be the cause of the retardation which we are considering. There are also electricians who will tell you that when magnetisation is suddenly evoked in an iron bar, there are induction currents set up in the iron which oppose and delay its magnetisation. That they oppose the magnetisation is perfectly true; but if you carefully laminate the iron so as to eliminate eddy currents, you will find, strangely enough, that the magnetism rises still more slowly to its final value. For by laminating the iron you have virtually increased the self-inductive action, and increased the time-constant of the circuit, so that the currents rise more slowly than before. The lag is not in the iron, but in the magnetising current, and the current being retarded, the magnetisation is, of course, retarded also.

Connecting Coils for Quickest Action.

Now let us apply these most important, though rather intricate considerations to the practical problems of the quick working of the electro-magnet. Take the case of an electro-magnet forming some part of the receiving apparatus of a telegraph system, in which it is desired to secure very rapid working. Suppose the two coils that are wound upon the horseshoe core are connected together in series. The coefficient of self-induction for these two is four times as great as that of either separately; coefficients of self-induction being proportional to the square of the number of turns of wire that surround a given core. Now if the two coils, instead of being put in series, are put in parallel, the coefficient of self-induction will be reduced to the same value as if there were only one coil, because half the line current (which is practically unaltered) will go through each coil. Hence the time constant of the circuit when the coils are in parallel will be a quarter of that which it is when the coils are in series; on the other hand, for a given line current, the final magnetising power of the two coils in parallel is only half what it would be with the coil in series. The two lower curves in fig. 54 illustrate this, from which it is at once plain that the magnetising power for very brief currents is greater when the two coils are put in parallel with one another than when they are joined in series.

Now this circumstance has been known for some time to telegraph engineers. It has been patented several times over. It has formed the theme of scientific papers, which have been read both in France and in England. The explanation generally given of the advantage of uniting the coils in parallel is, I think, fallacious; namely that the "extra currents" (*i.e.*, currents due to self-induction), set up in the two coils are induced in such directions as tend to help one another when the coils are in series, and to neutralise one another when they are in parallel. It is a fallacy, because in neither case do they neutralise one another. Whichever way the current flows to make the magnetism, it is opposed in the coils while the current is rising, and helped in the coils while the current is falling, by the so-called extra currents. If the current is rising in both coils at the same moment, then whether the coils are in series or in parallel, the effect of self-induction is to retard the rise of the current. The advantage of parallel grouping is simply that it reduces the time-constant.

Battery Grouping for Quickest Action.

One may consider the question of grouping the battery cells from the same point of view. How does the need for rapid working, and the question of time-constant, affect the best mode of

grouping the battery cells? The amateur's rule, which tells you to so arrange your battery that its internal resistance should be equal to the external resistance, gives you a result wholly wrong for rapid working. The supposed best arrangement will not give you (at the expense even of economy) the best result that might be got out of the given number of cells. Let us take an example and calculate it out, and place the results graphically before our eyes in the form of curves. Suppose the line and electro-magnet have together a resistance of 6 ohms, and that we have 24 small Daniell's cells, each of electromotive force, say, 1 volt, and of internal resistance, 4 ohms. Also let the coefficient of self-induction of the electromagnet and circuit be 6 quadrants. When all the cells are in series the resistance of the battery will be 96 ohms, the total resistance of the circuit 102 ohms, and the full value of the current 0·235 ampère. When all the cells are in parallel the resistance of the battery will be 0·133 ohm, the total resistance 6·133 ohms, and the full value of the current 0·162 ampère. According to the amateur rule of grouping cells so that internal resistance equals external, we must arrange the cells in four parallels, each having six cells in series, so that the internal resistance of the battery will be six ohms, total resistance of circuit 12 ohms, full value of current 0·5 ampère. Now the corresponding time-constants of the circuit in the three cases (calculated by dividing the co-efficient of self-induction by the total resistance) will be respectively—in series, 0·06 sec.; in parallel, 0·5 sec.; grouped for maximum steady current, 0·96 sec. From these data we may now draw the three curves, as in fig. 55, wherein the abscissæ are

FIG. 55.—CURVES OF RISE OF CURRENT WITH DIFFERENT GROUPINGS OF BATTERY.

the values of time in seconds, and the ordinates the current. The faint vertical dotted lines mark the time-constants in the three cases. It will be seen that when rapid working is required the magnetising current will rise, during short intervals of time, more rapidly if all the cells are put in series than it will do if the cells are grouped according to the amateur rule.

When they are all put in series, so that the battery has a much greater resistance than the rest of the circuit, the current rises much more rapidly, because of the smallness of the time constant, although it never attains the same ultimate maximum as when grouped in the other way. That is to say, if there is self-induction as well as resistance in the circuit, the amateur rule does not tell you the best way of arranging the battery. There is another mode of regarding the matter which is helpful. Self-induction, while the current is growing, acts as if there were a sort of spurious addition to the resistance of the circuit; and while the current is dying away it acts of course in the other way, as if there were a subtraction from the resistance. Therefore you ought to arrange the battery so that the internal resistance is equal to the real resistance of the circuit, plus the spurious resistance during that time. But how much is the spurious resistance during that time? It is a resistance proportional to the time that has elapsed since the current was turned on. So then it comes to a question of the length of time for which you want to work it. What fraction of a second do you require your signal to be given in? What is the rate of the vibrator of your electric bell? Suppose you have settled that point, and that the short time during which the current is required to rise is called t; then the apparent resistance at time after the current is turned on is given by the formula:—

$$R_t = R \times \epsilon^{\frac{R}{L}} + \left(\epsilon^{\frac{R_t}{L}} - 1\right).$$

(To be continued.)

THE ELECTRIC LIGHT IN ITS RELATION TO THE CONSUMER.*

By C. W. NAYLOR.

THE electric light is a broad subject for either study or discussion. It can be looked at from many directions. It is a theme for both the scientist and general student.

The mechanic or engineer who starts out intending to design or build electric machinery and appliances, maps out for himself a life-long course of study. To the speculative business man who makes and sells the electric light as a commercial product, it has an intense interest. The investor in central station apparatus takes a peculiarly pecuniary view of the electric light.

Still another class finds itself compelled by circumstances to investigate the subject of electric lighting. This class is composed of the consumers. The consumer is forced to consider it. His reflections lead him rapidly to conclusions. It is a powerful and easily controlled means of illumination, capable of regulation at will, it can be extinguished or relighted at pleasure, and instantaneously; it can be moved and removed from place to place. It is, moreover, a safe light—safe in the insurance or fire risk sense. It is not so expensive that it can be classed among the luxuries. It must, perforce, be admitted that the electric light is a plain every day matter of fact illuminant, and, as a practical thing, has come to stay with us. As such, it is to be gauged and measured by that worldly standard—the almighty dollar.

The question is, "Does it pay?" The answer involves an intricate problem.

What does it cost to make the electric light? To anticipate somewhat, it will be found that it is proportionately cheaper to generate it on a large scale. This fact is not surprising, for it holds true in the operation of most commercial apparatus.

For very small generating plants, the costs as compared with those of medium-sized or large stations are utterly disproportionate. To operate a few lamps only, by means of machinery, would be many times more expensive than any of the other ordinary means of lighting.

It will not be necessary here to claim everything for the electric light and insist that it is a necessity, and that everybody must sooner or later adopt it. It will be only a matter of a few years at most when the claim will make itself good.

There is no necessity that the advocate of electric lights should lose his composure or worry over the seeming slowness of men to appreciate this great boon to the commercial world.

In a very short time—we shall live to see the day—the electric light will reign supreme where people live thickly congregated and depend for existence upon their industry. As present users enlarge their plants, as new converts augment the demand for it, production will be cheapened, and thereby its field of usefulness will be increased.

How much will it cost to put in and operate an electric light equipment?

Assume for the time being that there is no machinery in an establishment, and that it becomes necessary to rent lights, the place in question being a small store or salesroom. The charge for one arc lamp to burn all day, say for 10 hours, will be 50 cents per day. This can be compared with the price that would be paid for gas light. Assume as a basis of comparison 10 gas jets. This comparison, however, is hardly fair to the electric light, as the illumination given by the latter is vastly superior to that of the gas.

Ten gas jets at an average consumption of 5 cubic feet of gas per hour per burner, at $1.25 per 1,000 feet will cost for 10 hours, 62½ cents. The electric light, as will be readily seen, is much the cheaper, is more powerful and penetrating, is cleaner, and vastly safer, so far as fire risk is concerned. It is switched on at once and off again just as quickly; it does not overheat the room: it will not ruin ceilings and walls with soot and grease, nor damage fabrics with deleterious, sulphurous and other gases. Gas cannot be obtained at a price much cheaper than that mentioned. Even at $1 per 1,000, the cost figured as before will reach 50 cents per day, which is fully as expensive as the electric arc.

This is the limit of economy in gas lighting. Should it become desirable to light a large room or a number of rooms gas cannot be had cheaper. On the other hand, electric lights are rated by a graded price list. If 5, or 10, or 20 electric lights are needed, they are to be had for 40 cents each per day, which is 20 per cent. less than the charge for gas. In fact, they can be contracted for at the low rate of 33 cents per day, almost 40 per cent. cheaper than the gas method of lighting. Gas light varies with the season and output, now weak, now strong. Sometimes it can hardly be coaxed out of the burners, at other times it flames to the ceiling. Now it is yellow and now red; it is very often blue, but very seldom white. In winter so sluggish is it that it is with difficulty cajoled into leaving its natural lair under the ground.

The electric light assures to the consumer at all times the full measure of an almost perfect illumination. With all its drawbacks it is wonderfully superior to any and all other known means of artificial lighting. There are numerous objections to the use of this light, most of them, however, are trivial.

Considering it from the dollar and cents point, to which we shall endeavour to confine ourselves, there arises the apparently serious objection that the lights cost whether they are kept burning or not. Gas can be turned on or off, and a saving thereby effected.

There are large commercial houses in this city with spacious and well stocked sales and display rooms that are kept for hours at a stretch in the deepest gloom. When a salesman leads a customer prospective or *bonâ fide* through the various departments, a boy or porter precedes him turning on the gas and turning it off behind him, as he passes with his buyer.

This is not exaggerated. It is a most ridiculous transaction and cannot possibly be economical. People who are compelled to do this would save money by renting a smaller store and lighting it up as it should be lighted.

* Read October 25th, before Illinois Branch No. 28, National Association of Stationary Engineers.

All the business done by an establishment of the kind cited above could be transacted in one-fourth of the space at present occupied.

One thousand dollars saved in rent and expended for electric lights or gas would make it possible to do a much larger business, and leave what is very desirable—a good impression on the trade.

To be consistent and follow out the line of policy exhibited in their scheme of lighting the store, these firms should dispense with their engineers and elevators and hire two or three strong labourers, who by patient industry might manage to carry, piece by piece, all their freight up and down stairs, day by day.

The electric light must be used in quantities to be really appreciated. A large business, however, cannot very well get along without it. Experience demonstrates the fact.

Among the firms in this city are scores that pay $25 or more for this means of lighting. Several expend upward of $40 or $50 per day, while one house expends not less than $100 hard cash each and every week day during the year for electric lights, and is not yet satisfied, but cries for more. It is not used as an advertisement. It is not a luxury, but a practical everyday attachment to the machinery of the establishment.

It will pay, and pay well. It does pay, and is paying. Use electric lights then, even if they must perforce be rented; but they are a much more profitable investment where the machines for generating the current are operated by the persons who are to use them.

The two principal items of expense going to make up the total cost of electric arc lights are fuel and labour. These two items constitute from 75 per cent. to 90 per cent. of all expense connected therewith. The cost of labour, which alone may amount to 50 per cent., 60 per cent., or even 80 per cent., of the total expense is the great stumbling-block in the way of operating a small plant. It is the only thing that requires special consideration when it has been decided to erect an outfit for operating fewer than 20 or 30 lights—of course circumstances have everything to do with the case and must be taken into account. For instance, a firm may have an engineer and a boy or young man with but little to do. These two together could operate a plant of 10, 20, or 30 lights at a minimum cost. The cost, possibly, would be as low as 12 cents or 15 cents per day per lamp, provided, of course, the time of neither the engineer nor the boy was charged to the expense of maintaining the lights. On the other hand, if an establishment has no engineer, no boilers, and no engine, and provides them especially in order that it may operate a plant of 10 lights' capacity, each lamp may cost it 45 cents., 50 cents., or even 60 cents per day, and that for less than 10 hours' run. The cost may reach as high as 75 cents or $1 for a full day of 10 hours.

These estimates have reference only to the ordinary arc lamp and do not apply at all to the incandescent lamp. The same engineer and assistant whose wages were included in the last estimate, could very easily run 40 or 50 lamps at a cost not to exceed 25 cents, or at most 30 cents daily per light. This last case assumes that the engineer and his assistant have nothing to do but run the lights, and that there are no elevators, no machinery, no heating to attend to. The engineer is assumed to receive $3 per day and the assistant $1.50 cents per day. If more is paid for help or less, the running price per lamp will vary about 4 cents or 5 cents per day one way or the other, as the case may be.

The work put upon the operator of a plant of this kind running about 30 lights and not to exceed 40 lights, leaves considerable spare time on the hands of the engineer who can then, with the assistance of a fireman, take care of two or three elevators in addition to their duties as electricians. If so, and this is a very common case, and a fair proportion of their time be charged to elevators and heat, and the other legitimate departments of the regular engineer's work, then the cost of lighting is reduced just that much. The whole process is in harmony with the general proposition that an engineer can care for more machinery and elevators and fewer electric lights, or for a greater number of electric lights and fewer elevators and other machinery. As the proportion of each kind of work varies, so the cost per lamp for operating the electric light will oscillate between 22 or 23 cents as a minimum and 28 or 30 cents as a maximum.

It can be assumed as an axiom in electric lighting that it requires at least 1 horse-power's worth of fuel to operate an arc light. One horse-power may mean 2 lbs. of coal, or it may mean 10 lbs. In general practice it means from 4½ lbs. to 8 lbs of fuel.

It will be contended that the former figure, 4½ lbs., or at most 5 lbs., is plenty large enough. Experience, however, will show that the coal bill at the end of the month, allowing for waste when starting, or banking fires, when the latter practice is followed, will tally best with a large or medium rate. We will figure, then, on a basis of 6 lbs. of coal, or its equivalent, if a different fuel is used.

Coal costs from $1.50 to $5.50 per ton, averaging between $2.25 or $2.50 and $3.25, according to quantity and quality. Assume that it costs $3 per ton of 2,000 lbs. A difference of 25 cents one way or the other from this price will not seriously affect the general result we are seeking. With 6 lbs. of coal per hour, the amount used in developing 1 horse-power or its equivalent, one arc light, will cost about nine-tenths of a cent per hour, or 8 cents to 9 cents daily for a 10 hours' run.

This estimate of 8 cents per day for fuel for each lamp is the basis upon which to build when estimating for electric lights. This item is fixed and unchangeable except in very small fractions. It is immaterial, practically speaking, whether the plant is to have 30, 40, 50 or even 100 lamps. The coal consumption per lamp remains virtually constant.

Exclusive of labour all other expenses connected with the operation of an electric light plant can be readily compared with the cost of fuel to which it bears a nearly fixed ratio varying from one-fourth to one-half of the fuel cost, or from 2 to 4 cents. per day per lamp. The average is generally midway between these extremes, and approximating, therefore, to 3 cents daily. It appears now that arc lights are to cost for fuel and other expenses, exclusive of labour and carbons, the sum of 11 cents per day.

To the cost again must be another added fixed charge, that for carbons. Although important, this item is unvarying and to simplify the matter, has been left untouched until this late moment. It is even more rigid in its effect upon the price of lights than coal. Carbons, or carbon pencils, as they are called, do not vary in price over 10 per cent. between any two systems of lighting, nor does the amount consumed per lamp vary much more than 10 per cent. in the different systems, provided the running hours are the same, and a similar general economy is practiced.

Carbons are very cheap now. Six years ago they cost $40 per 1,000; three years ago $12 per 1,000; to-day even less than $10 per 1,000. This great drop in price has effected a wonderful saving in the operation of electric lights.

Not less than one and one-half, and not more than three carbons per day per lamp are used. A very liberal estimate will allow for three carbons per lamp for the ten hours. If these carbons cost over a cent apiece, it is so little over that the fraction may be disregarded. Three cents a day is a very liberal allowance for this item of expense.

Add this to the 11 cents, and there is obtained a grand total of 14 cents per day per lamp as a measure of the operating expense attached to the generation and distribution of the electric arc lamps. it may be said that no risk will be incurred in accepting as accurate these figures of 8 cents for coal, 3 cents for incidentals, and 5 cents for carbons, and using them as standards.

In addition to these fixed values is the cost of labour, a most disturbing and widely varying element of wonderful importance, and demanding careful study. When it can be said that labour varies between one-half and nine-tenths of the total expense, it will be at once perceived how important a fact it is. Sometimes it is as low as one-half, or at least two-thirds of the established 14 cents, and, again, it is as high as five, six, or seven times that amount in proportion as the daily cost per light hovers between 22 cents per day and $1 per day.

The cost we are now discussing is simply the operating expense connected with generating and distributing the light. No account is here taken of those other important elements which go to make up the total amount expended or tied up in the effort to furnish to the consumer this steady, constant, artificial means of illumination—interest on the plant, depreciation on machinery and buildings, rent, taxes, insurance, accidental expenses, collections, advertising and management, together make up an enormous total, not less in any case than 100 per cent. of the operating expenses, and very often more—so it will be seen that arc lights can not very well be profitably sold for much less than 40 cents per day, although they are furnished by contract for as low as 35 cents, or may be a shade less.

In several cases lights are run for this amount and less, but they cost more. If a small central station makes a practice of furnishing them for so small a sum as 30, 32, or 35 cents, it is simply throwing away money or its equivalent, the valuable time of a manager who must work for next to nothing, and who could, without any serious effort, find much more profitable employment. It does not pay, taking trouble and worry and accident into account.

The investor, in an undertaking of this character, will soon discover that it does not return him dividends at all commensurate with the risk of capital involved.

These small central stations form one of the two classes of electric light furnishers which make lights at an apparently low cost. The other class embraces the public institutions, municipal corporations, and the like.

In a town in New York State, of which you have all probably heard, they claim to run the lamps for 12 cents per day. The city does this at its waterworks station, and does not figure in a cent for labour, rent, interest, taxes, water, management and the like, merely charging for coal and carbons. The labour, it is claimed, costs nothing, as the fireman and engineer are there anyway, and the water departments would have to pay their wages and all other incidental expenses.

Thus these lights cost apparently an insignificant 12 cents daily. It is an absurd calculation to omit in the estimate one of the most important elements.

In Maine there is a city that runs its lights by water power, and forgets to charge up the cost or rental value of that power in making the estimates, bringing the apparent cost of lights down to 16 cents daily.

Here, in Chicago, we have the spectacle of our municipal corporation claiming to furnish lights for 19 cents daily. The absurdity of the claim, and the fallacy of the arguments in support of the claim, were commented upon at the last National Electric Light Convention.

Electric lights are run cheaper in proportion as they are run in large numbers.

Let us take up for study one of the large city plants, and see how nearly the claim of 19 cents daily is borne out by the facts as nearly as we can get at them, and there will be no serious difficulty, for the stations are run wide open, and are public in their

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character. Nothing is concealed from the inquisitive searcher for knowledge.

The station in question is fitted up with mechanical stokers under 66-inch steel boilers, with the most approved setting, and is operated under a constant unvarying load. There is probably no greater variation than 10 horse-power, on a total of 500 horse-power from one day to another.

In the station referred to there are 18 dynamos belted direct from single acting automatic cut-off high speed engines, which take steam at 90 lbs. pressure, and exhaust into an improved feed water heater.

Of the 18 dynamos one or two are running idle, being in reserve. They consume very little power, not over 5 or 6 horse-power. The remainder of the dynamos are carrying a load of somewhat less than 450 lights, distributed over 30 or 40 miles of underground circuits.

Between 10 per cent. and 15 per cent. of the power is lost between the dynamo and the boiler which, added to an allowance of one horse-power for each light, gives a total of 520 horse-power being generated and consumed.

A very cheap coal is burned if we are to judge by the appearance and amount of ashes hauled out. Eight pounds per hour per horse-power, considering the style of engine used, would be a very fair measure, but to be doubly sure we will assume seven pounds per hour per horse-power; 520 multiplied by 7, gives 3,640 pounds of coal per hour.

The running time varies from eight hours in summer to fourteen hours in winter, depending upon the length of the night. The averaging is about eleven hours. It requires at least one hour's extra coaling to raise the steam before starting, as full steam must be had from the send-off, all the lights being thrown on within a period of 15 minutes. This makes a total of 12 hours, and 12 times 3,640 pounds, or 43,680 pounds of coal are used per day. At $2.10 per ton—a very low figure—the cost of coal is $45.86 daily. Assuming that one pound of coal evaporates seven and one-half gallons of water, there will be used daily, exclusive of water for washing out, cleaning, &c., about 44,000 gallons, which at 8 cents per 1,000 is worth $3.49. Gas for lighting while lamps are not running comes to 15 or 20 cents daily. Let us call it 15 cents.

Carbons are used at the rate of two and one-half per lamp, or 1,125 daily, which, at $8.50 per 1,000, cost $9.56.

Not less than four globes will be required daily at 50 cents each, which makes $2 per day for this item. Just here the city effects a great saving over the regular central stations and private operators of electric lights. If a globe used indoors cracks or a piece drops out, its usefulness has departed, and it must be at once replaced by a new one. Each renewal means an outlay of 45 or 50 cents. Out of doors on the lofty city poles three-fourths of the life of a globe is still in it after it has become cracked or slightly broken. It may seem strange, but the globe invariably lasts twice as long after a piece has fallen out as before, for the reason, no doubt, that it can expand and contract far more easily under great and sudden changes of temperature.

A careful inspection would show that about 80 per cent. of all globes on the street lamps in Chicago are cracked or broken; in fact, many of them are more hole than glass.

Brushes for the dynamo cost $1 per day, carbon holders for the lamp cost fully 50 cents per day. Dynamo and lamp repairs, commutator segments and screws, insulating wood, varnish and tape, oil cup glasses, renewals and repairs of tools, emery paper, crocus cloth, pliers, carbon kits, &c., cost not a cent less than $2 per day.

Cotton waste and wiping rags, gaskets, sheet and piston packings cost $1 per day at a low estimate.

The amount of lubricating and cylinder oils for engines, dynamos, and pumps will be six gallons daily, which at 50 cents will cost $3 per day.

The boilers and piping cost $15,000. The engines and belting cost $10,000. The dynamos and lamps cost $18,000; total, $43,000. Ten per cent. of this for wear and tear, and depreciation and renewals is $4,300 annually, or $11.77 daily.

The building cost $20,000; 5 per cent. for depreciation and renewals is $1,000 annually, or $2.75 daily.

The insurance on a total of $63,000 is not less certainly than $1 per day. The ground is valued at $20,000, making a total investment of $83,000; 4½ per cent. interest on this amount is $3,735 annually, or $10.23 daily.

This is a total amount, so far, of $94.32 daily, made up as follows:—

COST OF OPERATION.

Coal	$45 86
Water	3 49
Gas	15
Carbon points	9 56
Globes, lamp	2 00
Brushes, dynamo	1 00
Holders, carbon	50
Incidentals	2 00
Waste and packing	1 00
Oil	3 00
Wear and tear on machinery	11 77
Wear and tear on building	2 75
Insurance	1 00
Interest	10 23
Total	$94 32

In addition, there is the discord-breeding element of labour—costing as follows—as nearly as can be estimated without an actual reference to the pay roll.

COST OF LABOUR.

1 chief engineer	$4 00 per day.
1 first assistant	3 50 „
2 oilers at $2.25	4 50 „
2 boiler men at $2 25	4 50 „
4 firemen at $2	8 00 „
2 wheelers or passers at $1.75	3 50 „
1 watchman	2 00 „
1 line man	2 50 „
1 dynamo man	3 00 „
1 dynamo man	2 50 „
9 wiremen at $2	18 00 „
Total	$56 00

In the general official headquarters are employed a manager, a chief electrician, a superintendent, and a clerk, at an outlay of $30 per day for salaries. There is an additional item of $5 per day for office expenses, stationery, incidentals, &c., a total of $35 per day.

This, divided up among five stations, assuming that the city can operate that many plants with such an office force, gives $7 per day as the amount to be added to the foregoing $56 for wages daily, and the $94.32 daily expense previously estimated, making a grand total of $157.32 cost for each and every day, Sunday included, for the maintenance of nominally 450 lights. By simple division we find the cost to be 34$\frac{9}{16}$ cents. daily for one light.

This is a decided difference from the claim of 19 cents made by the authorities, and spread broadcast through the country. It may be thought by some the estimate is too high. It could not be shaved more than 10 per cent., even if it were high and the cost brought down to 31 cents. The difference, on a basis of 2,000 lights, between 19 cents and 31 cents, would amount annually to $87,600, quite a tidy little sum.

But that is immaterial, as we are not picking a quarrel with the city people, but rather making use of their experience as a guide to us in our effort to ascertain the cost of running electric lights. We do not feel inclined to allow the reduction of 10 per cent., as figured above, but hold to the opinion that the figure should rather be increased 10 per cent., that is to 38 cents or 39 cents daily per lamp, for perfect economy does not obtain in affairs political. What with incompetent and overpaid help, and there is always some of this—what with vacations, sickness, loss of time, inferior contract coal, and unexpected breakdowns—the total will invariably be considerably above our figures. Of the 34 cents, perhaps 25 per cent. is outside of what can be justly considered as operating expenses.

By operating expenses is meant everything except rent, depreciation on buildings, taxes, insurance, interest, and management.

Perhaps 26 cents or 27 cents will be a fair estimate of the actual daily running expense per lamp. This by careful business management can be somewhat reduced where the lights are used in any considerable number.

The question then arises, or may arise, how can the ordinary merchant with but a very few lights hope to produce them for less cost per lamp the city, when the latter has all the advantages inseparable from a large plant.

It must be borne in mind that there are several channels open for practicing economy, of which a public body or corporation cannot very well take advantage.

The city of Chicago follows a most liberal policy in the management of its institutions of every kind, including the electric light station. It is generous without being lavish or wasteful. It is further handicapped by long running hours, necessitating two separate shifts of men, with the accompanying heavy expense of labour. The many directions in which the private manufacturers of lights can cut down expenses have been partly brought forward in earlier portions of the paper, and partly suggest themselves. What has been done can be done again. We can repeat in our stores and shops that which we see is being done in our streets. The consumer can supply himself with arc lights for 25 cents or less, for even as little as 20 cents per day per lamp.

The lights in a large commercial house, not far distant from this location, cost approximately 21 cents per day, figuring 5 lbs. of coal per ton per horse-power with 1 horse-power, and 5 per cent. over charged to each light. The firm pays $3.75 a ton for coal. Carbons cost $10 per 1,000, considerably more than the price paid by the city, but the most rigid economy is practised in burning them. Not a scrap is wasted. Globes cost a little more than in the case of the city. Labour costs a little less per light. A summary of the items is about as follows:—

Eight cents per light for fuel.
Three cents per light for incidentals.
Two cents per light for carbons.
Eight cents per light for labour.

The total is 21 cents. An additional 5 cents per day per lamp will pay all the expenses, such as rent, interest, taxes, insurance, &c., and that can possibly be charged to the plant, will bring the total to 26 cents—a sum entirely within the means of the business man. The result obtained in the last case represents perhaps the utmost economy that can be attained where the lights are run as a dis-

tinct department of an institution, and agrees substantially with figures taken from the books of an establishment owning and running 200 arc lights. Here is an expenditure of no less than $52 daily. If gas was burned $125 worth per day would not give even an approximate equivalent light.

If lights are run from a single dynamo, which is cared for by the regular engineer of the establishment, and which takes up but little or no room in his department, the expense is cut down to as low as 15 or 16 cents daily. At such figures the light is really a necessity to a shrewd live merchant. The longer such a man puts off the adoption of the light in his business, just that much longer will he be behind his electrically-lighted rivals in the race for dollars.

The light has come to stay, and has taken its place with elevators and lifts as a necessary part of the machinery of an establishment that is forced to carry on its business in tall, deep, dark buildings, hemmed in on both sides by other buildings fronting on narrow streets and shut off from the light of day. It then becomes our duty as intelligent, progressive engineers, to seek at once for a better acquaintance with this method of illumination.

It will be found a most simple mechanical problem, on a par with the other machinery intrusted to our care, and no more difficult to manage than the ordinary elevators and engines. It is not at all mysterious. The atmosphere in the immediate vicinity of dynamos, converters and electric circuits is commonly supposed to be full of flying and flurrying volts, watts, ampères and other hidden subtleties. This need, however, occasion no alarm. They keep themselves in the background, and are not nearly so troublesome as hot boxes. The thoughts of them need deter no one from undertaking a study of them.

We have no more to fear from a volt than we have from a lateat heat unit. Who ever saw the engineer that was afraid of a latent unit of heat? Do not then fear the electric terms. They are but the hidden elements of the forces with which we will have to deal. Master them.

LONDON COUNTY COUNCIL.

AT the weekly meeting held on Tuesday, the following report of the Parliamentary Committee was presented:—

Overhead Wires Bill.

On the 28th October last the council, on the recommendation of the Highways Committee, passed the following resolution:—"That the council's Bill relating to overhead wires, in the form in which it passed the Select Committee of the House of Commons, subject, however, to such modifications as the Parliamentary Committee may consider necessary, be again introduced into Parliament next session; and that it be referred to the Parliamentary Committee to give the requisite notices and to take the other measures necessary for the purpose." In compliance with the terms of the above instruction, we have carefully considered the Bill, and have thought it desirable to omit clause 11 of the Bill of last session, which proposed to empower the council to make orders for carrying wires over, or supporting them, or attaching them to, private property. It will be remembered that this was one of the clauses upon which the opposition in the debate, which resulted in the rejection of the Bill, was based. With this exception the Bill remains as it left the Select Committee of the House of Commons. We have directed a copy of the Bill to be sent to each member of the council, and we recommend—

That the seal of the council be affixed to the petition for leave to bring in the London Wires Bill, and that the Bill be deposited with the petition, pursuant to the Standing Orders of Parliament, with such verbal alterations (if any), as the Parliamentary Committee may consider desirable.

Electric Lighting.

We have considered the following resolution passed by the council on the 18th November:—"That the Parliamentary Committee be instructed to insert in the Council's General Powers Bill of next session a clause giving the council power to require any electric lighting company to supply electrical energy to the council's electric testing stations, even if the station for which the supply is required be beyond the limits of the company's area of supply, and authorising such company, subject to the usual notices, to break up streets for the purpose of laying the mains necessary to afford such supply to the testing station." We have consulted the Parliamentary agent on the subject, and are advised by him that it is too late to insert such a clause in the General Powers Bill, the notices not having provided for it. We have accordingly referred the matter back to the Highways Committee for further consideration, and have directed the agent's report to be laid before them. We recommend—

That the reference to the Parliamentary Committee be discharged.

The Chairman of the Highways Committee presented the following report:—

The London Electric Supply Corporation has given notice (Registered No. 134) of its intention to lay a service line from the St. Martin's Vestry Hall in Charing Cross Road to the Electrical Standardising Institution in the same thoroughfare, and proposes to extend the line to the council's electric testing station in Cranbourne Street. We see no objection to the proposed works, and recommend—

(a) That the consent of the council be given to the laying by the London Electric Supply Corporation of a service line from the St. Martin's Vestry Hall, Charing Cross Road, to the Electrical Standardising Institution in the same road, and to the council's electric testing station in Cranbourne Street, upon the following conditions:—That the company do give two days' notice to the council's chief engineer before commencing the works; that the proposed line be laid in the subway; that the position to be occupied by the service line in the subway be subject to the approval of the chief engineer of the council; and that the work of placing it to be carried out to his satisfaction.

(b) That the clerk be instructed to forward to the company a notice requiring it to lay the service pipe, referred to in its notice (Registered No. 134), in the subway of the Charing Cross Road.

We have considered two notices from the Notting Hill Electric Lighting Company: one dated 14th November, 1890 (Registered No. 135), of intention to lay mains in Stanley Crescent and Gardens, and a part of Kensington Park Road (1 plan); and the other, dated 20th November, 1890 (Registered No. 136), of intention to lay mains in Pembridge Road from High Street, Notting Hill, to the corner of Ladbroke Road (1 plan). The works referred to in these notices are of the same description as those of this company previously sanctioned by the council; and we recommend—

That the sanction of the council be given to the works referred to in the notices (Registered Nos. 135 and 136), dated 14th and 20th November, 1890, respectively, of the Notting Hill Electric Lighting Company, upon condition that the company do give two days' notice to the council's chief engineer before commencing the work; that the cover stones of the culverts under 20 inches wide shall be not less than 2 inches thick, and of the wider culverts not less than 2½ inches; and that where the culverts cross the carriage-way, there shall be at least 9 inches thickness of Portland cement concrete above the cover stones of the culvert in addition to the road material.

The Kensington and Knightsbridge Electric Lighting Company has given two notices (registered No. 137 and 138), dated 21st and 26th November, 1890, the first being for extension of mains in Alfred Place West (1 plan), and the second for similar works in Church Street, Kensington (1 plan). There seems to us to be no objection to these works; and we recommend—

That the sanction of the council be given to the works referred to in the two notices (registered Nos. 137 and 138), of the Kensington and Knightsbridge Electric Lighting Company, dated 21st and 26th November, 1890, respectively.

The subject of the subway in its many phases has been agitating the minds of the council for some time. The Improvements Committee, in considering one section of the question, have arrived at the opinion that persons who use subways for laying pipes and wires should pay for the privilege, and at the meeting recommended an application to Parliament for powers to compel companies to use the subway, and to enable the council to charge a rent for such user.

PRACTICAL PROBLEMS.

1. *Provisional or Intermittent Employment of Accumulators in a Distribution of* 110 *Volts.*

THE first practical problem published in our paper on the 4th of October, has brought us a certain number of letters which have led us to explain more fully certain points which were, perhaps, touched upon too briefly.

The particular case which we considered, in the first place, concerned a reserve installation, in which the three or four lamps that were eventually to be fed by the accumulators would only work at long intervals—merely a few hours per week. Under these conditions, a current charging 3 to 4 ampères 3 or 4 hours a day, supplied every day to the battery from 10 to 15 ampère-hours, or from 60 to 90 ampère-hours per week, a quantity sufficient to feed the lamps kept in reserve for night service or any similar purpose.

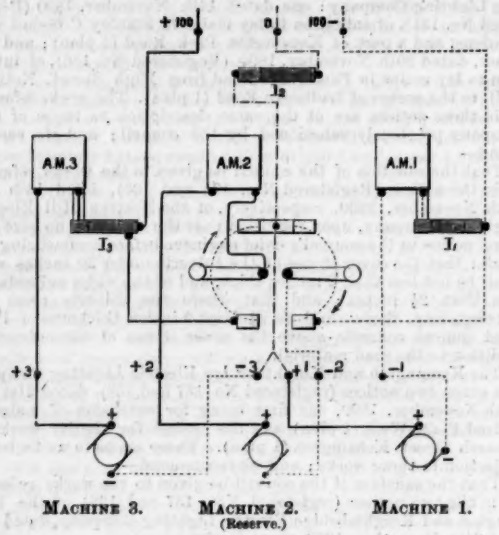
When the lamps are to work every day, it is evident that the number of 75-volt lamps placed in circuit with the battery of accumulators during the charge must be increased. The number of these lamps must be calculated in such a manner that the mean daily charge of the battery in ampère-hours exceeds by 10 to 15 per cent. the mean daily consumption in ampère-hours of the lamps supplied directly by the accumulators during the stoppage of the machine, this excess of 10 to 15 per cent. being calculated to take into account the rendering in quantity of the accumulators.

We do not think it necessary to give a diagram of

the mounting of the apparatus, it being very simple, and yet varying considerably according to the requirements of each case.

2. The Mounting of a System of Distribution with Three Wires.

The distributions with three wires, which are now pretty generally used, are particularly suited to the requirements of a small town, the population of which is not large enough for a service of distribution to be conveniently arranged with two wires, but yet too large for alternating currents and transformers to be employed.



MACHINE 3. MACHINE 2. (Reserve.) MACHINE 1.

The case of most frequent occurrence is that in which three shunt dynamos are used, two of which work at the same time, the third remaining in reserve, so as to be ready to be quickly substituted for one of the two others. Several methods have been adopted of connecting the system of canalisation with the machines and effecting readily the change of machines. One of the most simple is that adopted at the Œrlikon works, and which we have shown above. The six lower terminals of the system are connected respectively with the three shunt dynamos, 1, 2 and 3, machine 2 being the one in reserve, and the three upper terminals with the three distributing wires. Three ampèremeters are introduced respectively into the circuits of the three machines, in order to enable one machine to be substituted for another without any interruption of the service, by a simple manipulation of the exciting rheostats of the two machines between which the change is to be effected. Three interrupters, I_1, I_2, I_3, enable the three lines of the system to be completely insulated, in order to facilitate the testing of the insulation of the circuit of distribution.

Without dwelling further on the many advantages of this method over the distribution by two wires in the case under consideration, we will merely mention one that has up to the present been almost overlooked, and which consists in carrying on the distribution after midnight by means of a single machine, whilst two working at 200 volts can be employed for the full service, from nightfall to midnight. The plan of distribution must, in this case, be modified, the connection of the two circuits with one machine entailing a special manipulation which, however, presents no difficulty.—*L'Electricien*, October 18th, 1890.

LONDON GAZETTE NOTICES.

Provisional Orders.

ACCORDING to the *London Gazette* for the 28th November, the following corporations and public companies will apply to the Board of Trade for provisional orders: Surbiton Improvement Commissioners; Whitby Local Board; Harrogate Corporation; Tunbridge Wells Corporation; Torquay Local Board; South Shields Corporation; Electric Installation and Maintenance Company (Maidstone and Leeds); Camberwell and Islington Electric Light and Power Supply; Paddington and Bayswater Electric Light and Power Supply; Yorkshire House-to-House Electricity Co. (Leeds); Stamford Hill; Tottenham and Edmonton Electric Light and Power Supply (Hampstead and Wandsworth); Laing, Wharton and Down Construction Syndicate (Whitechpel, Hackney and Shoreditch); Brush Electrical Engineering Company (City of London, Southwark, North of London, and Poole); Messrs. Latimer-Clark, Muirhead & Co. (St. Martin's-in-the-Fields); Provincial Electric Light and Power Supply (Aberystwyth); Ipswich Electricity Supply Company, Messrs. Laurence, Scott & Co. (Ipswich); Windsor and Eton Electric Light Company; Manchester House-to-House Electricity Company (Withington District); Weymouth Electricity Supply Company.

Tramways.

The Birmingham Corporation and the Bristol Tramways and Carriage Company, in seeking authority to construct new tramways, specify electricity among other methods of traction which they ask permission to use.

PARLIAMENTARY NOTES.

The Wreck of the Serpent.

IN the House of Commons on Wednesday last, Lord George Hamilton, in reply to a question as to ships' compasses said:—There were four compasses on board the *Serpent*, including two of Sir William Thomson's, and they were adjusted and inspected on July 6th and November 8th this year. The compasses were inspected after the manœuvres by the superintendent of compasses, and found in excellent order. On the occasion of a subsequent visit, the commander expressed his own and the navigating officer's great satisfaction with the behaviour of compasses during heavy weather in the manœuvres of 1890. Sir. W. Thomson's compasses were introduced into the navy in 1884, and there are now very few of Her Majesty's sea-going ships that have not at least one.

Telegrams.

Last Friday, Mr. Hobhouse asked the Postmaster-General if it was the rule of the telegraphic department of the General Post Office to refuse to compensate persons for loss or expense consequent on the loss, delay, or non-delivery of a telegram, and to refuse to communicate to the person injured the names of the defaulting office or officials. Mr. Raikes in reply said:—If the hon. member will be so good as to refer to clause 6 of the notice which is printed on the back of the forms on which the public write their telegrams, he will find an answer to the first part of his question. The clause reads as follows:—"The Postmaster General will not be liable for any loss or damage which may be incurred or sustained by reason or on account of any mistake or default in the transmission or delivery of a telegram." As to the latter part of the hon. member's question, I may say that it is not the practice to give the names of the subordinate officials concerned in the transmission of a telegram or to name the office where a mistake may have occurred. Indeed, in a great many cases it would be impossible to do so, as it cannot always be ascertained with certainty where the fault has occurred or whether it is not due to some momentary disturbance of the wires or other apparatus. The conduct of any defaulting officials is always made the subject of strict inquiry by the department.

PROFESSOR HERTZ.

A LUNCHEON was given on November 30th at the Langham Hotel by Prof. W. E. Ayrton. This gathering of a few celebrities, more especially of those belonging to the electrical branch of the scientific world, had been invited to meet Prof. Heinrich Hertz. It is well known that this gentleman has been just presented with the Rumford Medal by the Fellows of the Royal Society, as a recognition of his valuable work in carrying on Clerk-Maxwell's investigations, and showing the connection between light and electricity. The luncheon was followed by a crowded reception, at which Prof. and Mrs. Ayrton welcomed, among others, Sir Frederick and Lady Abel, Dr. Lodge, Prof. Poynting, Dr. and Mrs. Hopkinson, Mr. and Mrs. Crookes, Mr. Norman Lockyer, Mrs. Fawcett, Prof. and Mrs. Hughes, Prof. and Mrs. Perry, Prof. Foster, Prof. and Miss Thorpe.

We need hardly say that everyone was eager to see the lion of the day. Heinrich Hertz is quite a young man, for he is only thirty-three; he is slightly built; of a pleasing, but by no means German, cast of countenance; he speaks English fluently, as was plainly shown at the dinner given by the Royal Society. He used to act as assistant to Prof. Helmholtz; but on his marriage he removed to Bonn, where he holds office as a Professor of Physics in the University. It was pleasant to hear how his attention had first been attracted by a simple laboratory observation, which led him ultimately to the successful termination of his labours. He may have contributed only one pillar towards the support of that arch upon which science has to build a superstructure, but, we take leave to say, that the pillar is a very substantial pillar. It is no slight work to have shown how electricity can, like light, be reflected and refracted; like light also it goes in straight lines, and its flash can be stopped by the interposition of a suitable apparatus; that its waves are transversal and not longitudinal. By his experiments and his conclusions Prof. Hertz has much simplified all work on radiation.

THE DINNER OF THE ROYAL SOCIETY.

(By A FESTIVE FELLOW.)

"WERE you at the dinner of the Royal Society?"

"No, sir, I was not. But as, I suppose, it was a grand day for electricians, I should much like to hear all about it from one who is acknowledged to be a light, indeed, in the electrical world."

"You are very kind. I must confess I felt very proud when I saw Sir William Thomson in the chair at our annual dinner in the Hôtel Métropole. It seemed too, that a Scotchman should occupy the chief place in a Society whose anniversary day is that dedicated to St. Andrew."

"Excuse me, but St. Andrew's Day is on November 30th, and you dined on——"

"The 1st of December. Quite so; but, you see, the 30th was on a Sunday; remember the weaker brethren. It would have been shocking to have a Presidential address and a dinner on the Sunday. Science, like other business, stands still on that day."

"Dear me, and does electricity cease to give light on that day, and sewers to give forth noxious gases, and fogs——"

"Pardon the interruption, but let me tell you about the dinner; that's a much pleasanter subject. I need not tell you that Stokes and Lubbock were there; the Lord Chancellor and a Marquis, the Italian Ambassador and Sir Philip Magnus. Professors abounded, Huxley and Hughes, Adams and Seeley, Hertz and Ayrton, Darwin and Lodge; sirs not a few—Sir D. Galton, Sir F. Abel, Sir B. Samuelson, Sir John—I mean—Sir Risdon Bennett, Sir A. This and Sir B. That; Doctors of medicine and of science; and the power of the purse was finely represented by the Masters of the Drapers' and Clothworkers' Companies. There were the heroes of the evening, the medallists, Prof. Simon Newcomb—no, he was absent—Prof. Hertz, Prof. Ferrier, Dr. J. Hopkinson, Mr. Lockyer and Mr. Crookes."

"Very interesting, no doubt; but after all, you know, a list of names, even of scientifically intellectual giants, is rather——"

"What a Philistine you are. Would you like me to give you the *menu*?"

"No, I wouldn't—certainly not; it's quite enough for me to know that you had your dinner at the Hôtel Métropole, and as you had invited the Masters of two great City Companies, I expect you put your best feet foremost and had a sumptuous 'bankwet,' as Robert would say. Tell me some of the coruscations of wit and fancy, which must have flashed electrically through the dining room."

"Well, sir, I don't know what you mean to insinuate, but when I am asked by a gentleman to give an account of a dinner, I expect to be allowed to tell it my own way."

"Of course; quite right; so you shall. You were saying, I think, sir, that the new President——"

"Yes, sir. I was going to say (only you interrupted me) that the new President proposed, on the removal of the cloth, the health of 'The Queen and Royal Family,' and rightly dwelt upon the loyalty of the Royal Society, for we are loyal and royal. Then came 'Her Majesty's Ministers and the Members of the Legislature.' This gave Sir William an opening to compare the Constitution to an engine, which had the imperfection of not working backwards, and not being free from friction. If a perfect engine was nearly realised in a steam engine, some slight approach to perfection might reasonably be looked for in the political machine. Anyhow, H.M. Ministers showed great devotion to the public service."

"How did Lord Halsbury take the suggestion?"

"Very good humouredly. He explained that the political engine was put together with very animated bolts and screws, so that much friction was unavoidable. He went on to propose the toast of 'The Royal Society,' introducing it with an anecdote about an orator, who asked a friend what he should say on a particular occasion.' 'To whom are you going to talk?' 'Oh, I'm going to talk to the Athenians.' 'Well, if you say something pleasant about the Athenians, they are sure to cheer you.' Acting upon this thought, the Lord Chancellor reminded his fellow-guests, how the light which enabled them to see each other was due to the researches of Sir William and men like him, who had made the great physical energies of the universe subservient to the use of mankind. He modestly drew in his horns after that; he felt nervous——"

"That's good! Lord Halsbury nervous! Beg pardon; you were saying——"

"He felt nervous lest some F.R.S. should tell him electricity was not physical, and was not an energy. Then he made the somewhat trite remark that electricity enabled us to receive news almost simultaneously from all parts of the world. To the legal mind, accustomed to the slow rate at which justice travels, I have no doubt this is an impressive fact about electricity."

"Did the president make a good speech in reply?"

"He very courteously, as the Italian ambassador was present, mentioned that the Academia in Florence and other societies were older than the Royal Society. But still two centuries and a half was a good age humanly, though not geologically speaking, and the Royal Society has been the fruitful parent of philosophical societies everywhere. By way of novelty, Sir William carried us back to what the Society did in the first 20 years of its existence. It took Newton—Sir Isaac Newton, you know—by the hand, and made known to the world outside Cambridge all his labours in optical research. Newton might be almost called the spoilt darling of the Society, for it was due to the indefatigable labours of

the Society's secretaries that Newton's work between 1665 and 1682 were published to the world. To Hook and Halley were chiefly due the publication of the 'Principia Mathematica de Motu Corporum. Sir William ended modestly enough; for while he felt the high honour conferred upon him, he could not but think that all credit for the Society's good work must be given to the Society's permanent officers. But the President's work was not over. He was up again, without even the interval of a song, to propose the medallists. Here again he enlarged rather more than was agreeable to most of his audience, upon the special work of some of the medallists; as he had given us a most detailed account of Newton, so he elaborated upon Newcomb and the rest. However, all things come to an end. It was time for Dr. Hopkinson to reply to the toast. With an occasional reference to notes, he told us how Newcomb had advanced Newton's theory of gravitation by applying it to the details of the motion of the moon and other planetary bodies; how Prof. Emil Fischer had furthered chemistry by synthetically producing from inorganic sources many definite sugars; how Wallace had chivalrously given way to Darwin; how Dr. Ferrier worked on the surgical treatment of the brain. When he reached that point, he bitterly denounced the restrictions on experimental work. I have no doubt he will hear further about that part of his speech from Miss Cobbe and the *Spectator*. With a pretty compliment to his foster-father in electrical and magnetic science, Sir William Thomson, that speech was ended. Our Bonn Professor, Hertz, next claimed our attention with a capitally-delivered speech, entirely in English, and spoken without any notes. He was fully aware of the high honour which had been done him. His only ground of apprehension when treading on English soil was that he would have to encounter a certain feeling of national jealousy; but, on the contrary, his first and most friendly communication was with those who might in ignorance be called his rivals, Dr. Lodge and Prof. FitzGerald. He was glad he had come to England to receive this medal, which was an earnest indeed of future work; for so had he seen, face to face, men whom hitherto he had worshipped only at a distance. Of this he was sure, that his work, so kindly praised, would sooner or later have been done by the men who so heartily welcomed him."

"Was there much more speech-making?"

"Sir John Lubbock proposed 'The Retiring President.' Perhaps, as you hail from Cambridge, you know the work he has done on the steady motion of incompressible fluids, on crystals and spectrum analysis. In reply, Sir Gabriel stated that he owed much to the Cambridge Philosophical Society, and, though he was retiring from the presidentship, he had no intention of resting from his labours as a member of the Council of the Royal Society. After 'Our Guests' had been proposed, and the Italian Ambassador and Sir Edward Hamley had replied to the same, we all said 'Good night,' and went our several ways."

REVIEWS.

Electric Bell Construction. By F. C. ALLSOP. E. and F. N. Spon, 125, Strand, London.

The substance of this book appeared as a series of articles in the *English Mechanic*. The work is thoroughly practical in its character, and is also very complete, almost every variety of bells and their allied mechanism being fully and carefully described. We are somewhat surprised, however, to find not a word said upon the construction of the Leclanché battery, indeed, the opening chapter, in which the general principle of a battery is described, might almost lead anyone to imagine that the Leclanché battery consists of a plate of copper and one of zinc in dilute sulphuric acid. Again, the description of the joining up of several cells in series would certainly lead one to suppose that Leclanché cells had no resistance, which is very far from being the case. A feature in the book is the fact that all the illustrations are drawn to scale, so that the dimensions of any of the apparatus can at once be obtained. Magneto as well as battery bells are described, and all details of their construction very fully explained. Altogether the book is a decidedly useful one.

Practical Electrical Notes and Definitions. By W. Perren Maycock. Second Edition. E. and F. N. Spon, 125, Strand, London.

The second edition of this book is a decided advance on the first, though we observe that the rhapsodical rubbish, to which we drew attention in our notice of the first edition, still remains. The book, in its present form, hardly accords with its shape, which is of the pocket-book pattern, and we do not expect in such books to find illustrations of machines which are left undescribed, though, possibly, these illustrations may be useful to amateurs as a means of identifying any particular machine they may come across. On page 203, it is stated that a microphonic relay receives a message and transmits it afresh over another section of line; we are quite certain Mr. Maycock has never seen such a relay at work, for no one has yet succeeded in making one. Although the whole work contains much useful matter in the shape of notes, tables, diagrams, rules, &c., there is, we think, a good deal too much space devoted to "definitions," which are unsatisfying in their character, and might be more profitably replaced by something more practical. We notice that the use of the modern terms "conductance," "resistivity," &c., has been introduced. The whole work has had the advantage of having been "overlooked" by Professor Silvanus Thompson and Mr. J. Swinburne; quite so!

The Electric Light Popularly Explained. By A. BROMLEY HOLMES. 5th edition. London: Bemrose and Sons, 23, Old Bailey.

The first edition of this book was published in 1882, and the fact that a fifth edition has been called for speaks well for the production. A good deal of additional matter has been worked in and revision carried out. The last chapter, which deals with the "Cost of the Light," is, perhaps, hardly entirely satisfactory; but, then, the subject is one which it seems almost impossible to fairly get at.

Physical Memoirs: selected and translated from foreign sources, under the direction of the Physical Society of London. Vol. I., part 3. London: Taylor and Francis, Red Lion Court, Fleet Street.

This issue consists of a paper by Prof. J. D. Van der Waals, on "The Continuity of the Liquid and Gaseous States of Matter."

THE QUESTION OF PUBLIC LIGHTING IN BUDAPEST.

[FROM A CORRESPONDENT.]

BY the occasional insertion of moderately circumstantial communications, you have kept your readers acquainted with the different phases of this question in Budapest. They will probably read with interest the following extract from the recent report of the Commission on Public Lighting, especially as it furnishes a clear view of the genetic development of this affair, which is calculated to prove instructive to other municipal bodies.

The sub-committee appointed for the especial conduct of the negotiations obtained in the first place an opinion from the Director of Buildings (an official somewhat like the "Dean of Guild" in a Scottish

city), the head accountant, and the chief fiscal. The prevalent opinion, in accordance with the explanations received, was to the effect that "in view of the revolution now taking place in the sphere of public lighting, it did not appear suitable to take the use of any other new means of lighting into serious consideration, and that "the question of the redemption of the gas-works could be advantageously considered only if the valuation provided for in the agreement had been carried out, and the capital required for the redemption had been approximately estimated. All this, however, was no reason why the metropolis should not make use of the right secured to it under section 4 of the gas agreement, concerning the (partial) adoption of a new system of lighting.

Proceeding from the point of view just indicated, the sub-committee invited the gas company to declare whether, and under what conditions, it was prepared to supply electric lights, on the one hand, for public purposes, and, on the other, for private consumers. Further negotiations were to be opened with the gas company to ascertain whether, and under what conditions, it was prepared to concede a reduction of price for the private consumption of gas before the expiry of the agreement, and undertake the private lighting gratuitously?

The gas company replied, in the communication of September 5th, 1889, that, in accordance with the wish of the city, it was prepared to undertake the introduction of the electric light on certain conditions (enumerated in detail), and in return for a prolongation of the gas agreement for 10 years, gradually to reduce the price of gas to private consumers to 11 kreutzers, and to supply the street lighting gratuitously on the basis of the quantity consumed in 1888, so that the city would only have to keep the street lamps in order.

After ripe deliberations, the sub-committee resolved that the conditions for the introduction of the electric light were too onerous, and that the gas company would thus obtain a monopoly of the electric light. Hence the offer, as it stood, could not be accepted, but, with considerable modifications, it might be taken as the basis of further negotiations. "Hence the sub-committee—considering that the redemption of the gas-works would be unreasonable, since there is a general movement in the matter of public lighting, and new technical advances and inventions are daily coming forward—did not object to a prolongation of the agreement, but urge that it must be made a fundamental principle that with such prolongation the monopoly of the gas company for the introduction of any illuminating agent must expire, and the capital must have its hands in this respect unfettered. The conditions of the committee were in fine the following: A ten years' prolongation of the gas agreement, reduction of the price of gas to private consumers to 10 kreutzers per cubic meter; free supply of the street lamps without reimbursement for the expense of their erection; no exclusive right or privilege for the electric or any other new light; finally, the stipulation that the price of the electric light for the street lamps must not be higher than that of the gas lamps at present.

On March 31st, 1890, the desired explanation of the gas company was handed in. It was willing to forego the exclusive right of introducing any new means of illumination which had been secured to it by contract. If the gas agreement were prolonged for 15 years the company was willing to concede to the municipality the unlimited right of disposal; the price of the gas supplied to the private consumers should be reduced to 10½ kreutzers; the gas required for street lighting should be furnished gratuitously after the expiry of the present agreement, and after the cost incurred for maintaining the lamps according to the proportion of 1888 had been refunded.

The municipal accountant calculated that these conditions—disregarding the great value which the surrender of the exclusive privilege possesses—would involve yearly a saving to private companies of 1,250,000 florins during the time of the present agreement, and that it would imply for the community a yearly economy of 240,000 florins, dating from December 16th, 1895, and it would consequently be acceptable with the following modifications and additions. 1, The city is to be free after 10 years to redeem the gasworks; 2, the private gas price to be reduced to 10 kreutzers; 3, half the cost of the street lighting is to be at once given up, and the rest after the expiry of the present agreement; 4, the city to refund only half the cost of maintenance of the gas-lamps; 5, the gas to be supplied gratis for the streets is to be calculated according to the consumption of 1889, taken as a minimum; 6, the gas company to establish an independent management in Budapest.

To these more recent proposals the gas company replied on June 12th, 1890. The redemption of the gasworks before the expiry of the 15 years cannot be accepted; the company accepts the reduction of the private gas price to 10 kreutzers, on condition that the production cost of gas does not rise, and that no further sacrifices are to be required for public purposes. The immediate surrender of half the cost of public lighting, and half the cost of maintaining the lamps cannot be conceded. The proportion of consumption for 1889 is accepted, but not as a minimum, but either as a fixed or a variable yield. The local direction of the gas company will be invested with powers to decide on the spot all affairs concerning the Budapest Gas Works.

Therewith the negotiations were completed, and the General Commission resolved to accept the offers of the gas company, with the following supplements:—The ultimate redemption of the gas works will not take place before the lapse of 15 years' agreement; the price for private gas, not to be used for lighting, to be reduced to 8 kreutzers per cubic metre; the proportion of consumption of the gas to be supplied gratis for street lighting is to be assumed as variable, adhering to the proportions of 1889. Several gas testing stations are to be erected in the city, and the price of the gas consumed in municipal buildings is to remain in future 7.42 kreutzers for cubic metre.

NOTES.

Removal.—Messrs. Nalder Bros. have now removed their offices and works to their new premises at 16, Red Lion Street, Clerkenwell.

Fire at an Electrical Engineers.—Last Saturday afternoon a fire broke out on the premises of Messrs. Gent and Co., electricians, Leicester. It was, however, extinguished before much damage was done.

The Delany Battery Strip.—This is a simple contrivance, invented by P. B. Delany, of South Orange, N.J., to prevent the creeping of salts in the gravity, Leclanché, and other primary batteries. The device is simply a strip made of rubber cloth and applied to the inside of the rim of the battery jar. One side of the strip is covered with a sticky compound, and when the strip is properly applied it will never come off the jar. The strip offers a mechanical obstruction to the creeping salt which masses underneath it, and is re-dissolved in the battery fluid each time that water is added to the solution to make up for evaporation. All waste and exhaustion of batteries by local action by this means, it is claimed, is prevented, and shelves are kept perfectly clean and dry. When the strip is properly applied no amount of washing or wetting will affect it.

Telephonic Communication with Lighthouses.—Henley's Telegraph Works have recently manufactured a submarine telephone cable which has been laid by the Pilot authorities in Finland between Hanzo, the most southern point of Finland, to a lighthouse 2½ miles from the coast. We hear that the cable has been found to work well.

Royal Society's Medal.—Dr. Hopkinson will receive the Royal Society's medal for his researches in magnetism and electricity.

Proposed Electric Railway in Vienna.—In connection with the underground railway projected for Vienna, the Austrian Minister of Commerce has resolved to send two engineers to London to study the underground electric railway recently established between the City and South London.

The Old Students' Association.—The first smoking concert of the season, in connection with this association, was held at Mason's Hall Tavern on the 28th ult., Mr. W. B. Esson, the president, occupying the chair. The musical programme was of a first-class character, and in point of numbers the concert was a great success, there being not an empty seat in the room. Amongst those present were:—Vice-Presidents A. Reckenzaun and A. T. Snell, Past-Presidents Dr. W. E. Sumpner and Mr. Adams, Profs. Ayrton and Perry, Mr. L. B. Atkinson, Mr. John Gray, B.Sc.; and Mr. Holland, B.A. A cordial vote of thanks was given to the performers and to the musical committee. There is but little doubt that the O.S.A. has reached a new era in its existence, and with such energetic directors there is now nothing to prevent its growth into a body which will eventually fill an important position in the scientific world, and at the same time possess social qualifications which will keep its members continually in touch with one another.

An ordinary general meeting was held at Finsbury Technical College last night, when a paper was read by Hamilton Kilgour, member, on "Notes on Economy of Conductors in Systems of Distribution in Electrical Energy."

S.S. Silvertown.—This telegraph steamer, owned by the India-Rubber, Gutta-Percha, and Telegraph Works Company, is reported to have arrived at Coronel (Chile) on November 25. It will be remembered that she carries the submarine cable for extending the Central and South American Telegraph Company's lines from Lima, where they at present terminate, to Yquique and Valparaiso.

A French Manufactory of Submarine Cables.—A Calais telegram to the *Temps* says:—The factory for the manufacture of submarine cables, which the General Telephone Company is constructing at Calais, to the east of the Carnot basin, is finished. The opening will take place, we are told, in the early part of December. The building of this factory is, from a national point of view, of real importance, since, up till now, England alone possessed a monopoly of submarine cable-making.

The Aron Meter.—Dr. Aron's electricity meter received a gold medal at this year's exhibition at Palais de la Industries at Paris.

Provisional Orders.—The time limited by the Electric Lighting Act within which official notice must be given of all provisional orders, expired on the 28th ult. From the notices given it appears that 76 separate orders will be applied for, 17 of them relating to various portions of London and suburbs.

Electric Light in Hampstead.—The Hampstead Vestry will oppose all applications made by companies or others to the Board of Trade for powers to light the borough by electricity. It has empowered its Electric Lighting Committee to obtain a plan and estimate from a specialist so that it may consider the advisability of undertaking the work itself.

Theatre Lighting.—Messrs. Dickinson & Co. have secured from Mr. Norman Forbes a contract to instal the electric light throughout the Globe Theatre.

Mr. Muirhead and the National Telephone Company.—We have received another and rather lengthy letter from Mr. Muirhead, which, however, shows no improvement in the relations with the telephone company. We do not see that anything is to be gained on either side by allowing further correspondence on this subject.

Gas and Electricity in Bordeaux.—The Bordeaux Gas Company is now lighting the stage of the Grand Theatre by electricity. The offices of the company are also lighted electrically, and the plant is installed on the latter's premises.

New Telegraph Cable.—A Bill approving of the agreement made on October 12th last with the Grande Compagnie des Telegraphes du Nord for the laying and working of a second cable between Calais and Fanoë in Denmark has been presented to the French Chamber of Deputies. The new convention reserves to the State certain advantages, in exchange for which it gives to the company financial assistance, which, for the two cables, will not exceed £6,800.

New Central Station in Vienna.—The central station of the International Electricity Company was put in operation on the 14th ult. About 21 miles of cable have been laid throughout the town and suburbs.

Lighting of Karánsebes.—This small town in the south of Hungary is now lighted electrically, the plant being installed in a saw mill. In addition to the public illumination, 500 lamps for private consumers are in use.

New Battery Company.—The Compagnie Francaise des Piles Universelles has been formed in Paris with a capital of £8,000 divided into 200 shares of £40 each.

Edinburgh Exhibition.—In our notice of the exhibits at the Edinburgh Electrical Exhibition, we called attention to the very fine display made by Messrs. Buller, Jobson & Co., Limited, now Bullers, Limited, of Birmingham, Hanley, Dudley, Glasgow and London, of telegraph insulators, brackets, clips, poles, stay rods, channel arms, and all the various articles made by them for telegraphic, telephonic and electric lighting purposes. Facing the index to advertisements will be found an illustration of this unique exhibit, which arrested the attention of every visitor to the machinery hall. This old-established firm, as our readers are aware, has lately purchased an extensive site at Cheston Road, Birmingham, for the erection of a new works with modern plant, suitable for the production of its manufactures. Those engaged in telpherage will be interested to know that Messrs. Bullers, Limited, are supplying an insulator patented by Mr. E. J. Chambers (a director of the company), which is arranged to grip and insulate the cable at the same time, and to allow the grooved wheels of the travelling carriage to pass easily over the tops. These insulators are shown at the left hand corner of the illustration. We understand that Messrs. Bullers, Limited, will exhibit at the Glasgow Industrial Exhibition.

Electric Welding.—Sir Douglas Galton, K.C.B., Mr. W. H. Preece, F.R.S., Mr. Ashton (of the Royal Laboratory, Woolwich), and other gentlemen, visited Messrs. Lloyd and Lloyd's Coombes Wood Tube Works on Friday last, for the purpose of inspecting their installation of electric welding. The process used is that known as the Bernardos process, the sole right to the use of which has been acquired by Messrs. Lloyd and Lloyd, and the welding is, as our readers are already aware, effected by means of the arc. The distinguished visitors were much delighted with all they saw, and expressed themselves most favourably as to the achievements and possibilities of arc welding.

Telephony on the Congo.—The *Ville de Ramanaho*, which recently left Antwerp for the Congo, had on board the wires, &c., necessary for the installation of the first telephone line to be erected along the Congo railway. The wire is of phosphor bronze, and the apparatus is of the type adopted by the administration of the Belgian Telegraphs for their private and service lines.

The Institution of Electrical Engineers.—The annual general meeting of the Institution will be held on Thursday, December 11th, at 8 o'clock in the evening, for the reception of the annual report of the Council, and for the election of Council and officers for the year 1891. The following papers will be further discussed :—"The Efficiency of Secondary Cells." "On the Chemistry of Secondary Cells." By Prof. W. E. Ayrton, F.R.S., Vice-President, C. G. Lamb, B.Sc., and E. W. Smith, Associates.

Telephone Switchboards.—We have received a long communication from Mr. Hubert F. Jackson on "Improvements in Telephone Exchange Switchboards." Unfortunately it came to hand after the bulk of our pages had gone to press, so we must perforce hold it over till next week.

Death from Electricity.—Reuter telegraphs from St. Louis, United States :—An electric light company's *employé* came into contact with an electric light wire here on Saturday and was immediately killed.

NEW COMPANIES REGISTERED.

Holmes and Sons, Limited.—Capital £14,000, in £5 shares. Objects : To take over the business of Holmes and Sons, engineers, of Norwich, and to trade as mechanical engineers, machinists, metallurgists, and electricians. Signatories (with 1 share each) : *Garrett Taylor, *James Holmes, *G. T. Holmes, F. R. Holmes, all of Norwich ; *Clare Sewell Read, Thorpe, Norfolk ; *C. Waters, Postwick, Norfolk ; *J. W. Reynolds, Keswick, Norfolk. The signatories denoted by an asterisk are the first directors. Qualification, 50 shares. Remuneration, £150 per annum, divisible. Registered 24th inst. Solicitor, Mr. S. Cozens Hardy, Norwich.

Weymersch Electric Battery Company, Limited.—Capital, £20,000 in £5 shares. Objects :—To carry on the business of an electric light company in all branches, and to enter into an agreement with Hy. Weymersch, Leoné Sara McKenzie and Arthur McKenzie Cardwell. Signatories (with 1 share each) : *A. M. Cardwell, 29, St. James' Street ; *H. Weymersch, 17, Glengarry Road, E. Dulwich ; W. S. T. Martin, 17, Melbourne Grove, E. Dulwich ; E. C. de Segundo, 7, Victoria Street, Westminster ; F. Fanta, 10, Moorgate Street ; C. F. Jones, Fox Hill, Upper Norwood ; Mrs. L. S. McKenzie, 21, Talbot Road, Bayswater. The first directors are the first two signatories and T. H. Cardwell and W. A. Cardwell. Qualification, 100 ordinary shares, and the company in general meeting will determine the remuneration. Registered, 28th ult., by Harwood and Stephenson, 31, Lombard Street. Registered office, 2, Victoria Mansions.

J. & S. Roberts, Limited.—Capital, £120,000 in £10 shares. Objects :—To take over the business of ironfounders carried on by Messrs. John and Samuel Roberts at the Swan and Small Heath Foundries, West Bromwich, and to carry on business as ironmasters, mechanical and electrical engineers and manufacturers of electric plant and appliances. Signatories (with 1 share each) : *John Roberts, *S. Roberts, *J. Hampton, James Roberts, *Hy. Roberts, Thos. Roberts and W. A. Roberts, all of West Bromwich. The signatories denoted by an asterisk and H. J. Roberts, Isaac Jenks and Walter Jenks are the first directors. Qualification, 50 fully paid ordinary shares. Registered, 20th ult., by Sharpe, Parker & Co., 12, New Court, Carey Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Elmore's French Patent Copper-Depositing Company, Limited.—An agreement of 10th September between Elmore's Foreign and Colonial Copper-Depositing Company, Limited (the vendors), of the first part, Woodhouse and Rawson United, Limited, of the second part, and this company of the third part, provides for the sale to this company of the French patents of the vendor company, the consideration being as follows : £8,350 within seven days of going to allotment, £75,150 in cash, and £66,500 in fully paid shares, and a premium of 10s. each on any of the 66,750 shares issued to the public which may be allotted to any person or persons other than the vendors. Provided always that should the Woodhouse Company consider that applications for shares in this company, over and above those to be allotted to the vendors are insufficient, then the company shall be at liberty to pay any part of the said cash in fully paid shares at par. Under this agreement Francis Edward Elmore and Alexr. Stanley Elmore are appointed standing consulting metallurgical chemists of the company for three years at a remuneration of £100 per annum each. Registered office, 64, Cannon Street.

Elmore's Austro-Hungarian Patent Copper Depositing Company, Limited.—An agreement of 26th September, filed 20th October, provides for the purchase by this company of the patents for Austria-Hungary belonging to Elmore's Foreign and Colonial Patent Copper-Depositing Company, Limited. The purchase consideration is £10,000 in cash within seven days of going to allotment ; secondly, £40,000 in cash and £50,000 in fully paid shares, and a premium of 10s. each on any of the 75,000 shares issued to the public which may be allotted to any person or persons other than the vendors, with the same discretionary power to the Woodhouse Company as in the French Company, for the payment of any part of the said cash in fully paid shares at par. Messrs. Francis Edward Elmore and Alexr. Stanley Elmore are appointed standing consulting metallurgical chemists of the company, at a remuneration of £100 per annum each.

Metropolitan Electric Supply Company, Limited.—The annual return of this company, made up to the 21st ult., was filed 27th ult. The nominal capital is £500,000, divided into 49,900 ordinary, and 100 founders' shares of £10 each. The shares taken up are 45,932 ordinary, and 100 founders', and of these 2,132 are considered as fully paid. Upon 43,900 shares £8 per share has been called, the calls paid amounting to £342,598 9s., and unpaid to £8,601 11s.

Brazilian Submarine Telegraph Company, Limited.—The directors of this company have to-day declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The estimated traffic receipts for the month of November were £3,100 as compared with £3,112 in the corresponding month of last year. The receipts for the month of August estimated at £2,900, realised £2,913.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of November show £2,702 against £2,497 in the corresponding period of last year.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for the month of November, 1890, amounted to £44,742, as against £44,147 in the corresponding period, an increase of £595.

The Eastern Telegraph Company, Limited. The receipts for the month of November were £58,975, as against £60,578 for the same period of 1889, or a decrease of £1,603.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending November 28th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £5,016.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month of November, 1890, were £4,350.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (November 27).	Closing Quotation. (December 4.)	Business done during week ending December 4, 1890. Highest.	Lowest.
250,000l	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	98 —101	100½	...
1,381,380l	Anglo-American Telegraph, Limited	Stock	48½— 49½	48½— 49½	49⅜	48⅜
2,809,310l	Do. do. 6 p. c. Preferred	Stock	85 — 86½	85 — 86	86⅛	85⅛
2,809,310l	Do. do. Deferred	Stock	13½— 13⅝	13½— 14	14⅛	13⅞
130,000	Brazilian Submarine Telegraph, Limited	10	11½— 11⅝	11½— 11⅝	11⅝	11½
84,500l	Do. do. 5 p. c. Bonds...	100	101 —103	101 —103		
75,000l	Do. do. 5 p. c. 2nd Series, repayable June, 1906	100	104 —108	104 —108		
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	1 — 1½	1½— 1⅝	1 9/16	1½
63,416	Do. do. Preference, Nos. 1 to 63,416 ...	2	1¼— 1⅝	1½— 2	1⅝	1⅝
$7,216,000	Commercial Cable, Capital Stock	$100	102 —104	102 —104		
224,850	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	7/16— 9/16	7/16— 9/16		
20,000	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	Stock	5⅛— 5⅜	5⅛— 5⅜		
16,000	Cuba Telegraph, Limited	10	11½— 12	11½— 12	11⅞	11½
6,000	Do. do. 10 p. c. Preference	10	17 — 18	17 — 18		
12,931	Direct Spanish Telegraph, Limited ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼		
6,000	Do. do. 10 p. c. Preference	5	8½— 9½	9 — 10	9¼	...
60,710	Direct United States Cable, Limited, 1877	20	10 — 10¼	10⅛— 10⅜	10⅜	10 3/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	13⅜— 14⅛	13⅜— 14	14	13⅞
70,000	Do. 6 p. c. Preference	10	14½— 15	14½— 15	14⅝	14 1/16
200,000l	Do. 5 p. c. Debs. (1879 issue), repay. Aug., 1899	100	106 —109	106 —109		
1,200,000l	Do. 4 p. c. Mortgage Debenture Stock	Stock	103 —106	103 —106	105½	104½
250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	13⅞— 14	13⅜— 14	14	13⅜
320,000l	Do. 6 p. c. Debentures, repay. February, 1891	100	100 —102	101 —103		
91,800l	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049 3,976 to 4,326	100	102 —105	102 —105		
325,200l	Do. do. Bearer Nos. 1,050—3,975 and 4,327—6,400 ...	100	102 —105	102 —105		
145,300l	Eastern and South African Tel., Ld., 5 p. c. Mort. Deb., 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	101 —104	101 —104	102⅜	...
198,200l	Do. do. do. to bearer, Nos. 2,344 to 5,500	100	101 —104	101 —104		
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	7⅜— 8½	7⅜— 8½		
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4⅜— 5⅛	4⅜— 5⅛		
70,000	Elmore's Patent Copper Depositing, Ltd., Nos. 1 to 70,000 ...	2	3⅛— 4	3⅛— 4	5 1/16	...
67,385	Elmore's Wire Manufacturing, Limited, Nos. 1 to 67,385 issued at 1 pm. all paid	2	1⅞— 2⅛	1⅞— 2⅛	3 1/16	3⅛
20,000	Fowler-Waring Cables, Nos. 301 to 20,000 ...(£4 only paid)	5	2⅛— 3⅛	2⅛— 3⅛	2 1/16	1⅞
180,227	Globe Telegraph and Trust, Limited	10	8⅛— 9⅛	8⅛— 9	9	8 1/16
180,042	Do. do. 6 p. c. Preference	10	14⅝— 15	14⅛— 14⅝	14⅞	14⅛
150,000	Great Northern Tel. Company of Copenhagen	10	15⅜— 16⅛	15⅜— 16⅛	16⅛	15⅞
15,000l	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	101 —104	101 —104		
230,000l	Do. do. do. (issue of 1883) ...	100	104 —107	104 —107	106½	...
9,384l	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	11½— 12⅛	11½— 12⅛		
5,334l	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11½— 12⅛	11½— 12⅛		
41,800	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	18 — 19	18 — 19	18⅞	18½
200,000l	Do. do. 4½ p. c. Deb., 1896...	100	100 —102	100 —102		
17,000	Indo-European Telegraph, Limited...	25	35 — 37	35 — 37		
11,334	International Okonite, Ltd, Ordinary Nos. 22,667 to 34,000 (£7 pd.)	10	6½— 7½	9½— 10		
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	6½— 7½	9½— 10		
38,348	London Platino-Brazilian Telegraph, Limited	10	6 — 7	6 — 7		
100,000l	Do. do. do. 6 p. c. Debentures ...	100	105 —108	105 —109	108	...
43,900	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 £8 pd.	10	6¾— 7½	6¾— 7½	7½	7
438,984	National Telephone, Limited, Nos. 1 to 438,984	5	4¼— 4⅝	4¼— 4⅝	4 5/16	4¼
15,000	Do. 6 p. c. Cum. 1st Preference	10	12½— 12⅝	12½— 12⅝		
15,000	Do. 6 p. c. Cum. 2nd Preference (£8 only paid)	10	9½— 10½	9⅜— 10½		
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11/- only paid)	1	⅛— ¼	⅛— ¼		
9,000	Reuter's, Limited	8	8½— 9	8½— 9	8⅝	8½
209,750	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼		
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2½— 3	2½— 3		
3,381	Submarine Cables Trust	Cert.	113 —117	108 —112		
78,949	Swan United Electric Light, Limited ... (£3½ only paid)	5	4½— 5 xd	4½— 5	4 15/16	4½
37,350	Telegraph Construction and Maintenance, Limited	12	43 — 45	43 — 45	44	...
150,000l	Do. do. do. 5 p. c. Bonds, red. 1894	100	100 —102	100 —102	102	..
58,000	United River Plate Telephone, Limited	5	3 — 4	3 — 4		
146,128l	Do. do. 5 p. c. Debenture Stock... ...	Stock	90 — 94	90 — 95		
3,200l	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
15,809	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8½— 9½	8½— 9½	9	...
290,900l	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101		
30,000	West Coast of America Telegraph, Limited	10	4 — 5	3½— 4½		
150,000l	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	102 —107	102 —107		
64,174	Western and Brazilian Telegraph, Limited	15	10½— 11 xd	10⅜— 11⅛	11	10⅜
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6¾— 6¾xd	6¾— 6⅜	6⅞	6 7/16
27,873	Do. do. do. 5 p. c. Deferred	7½	4½— 5	4½— 5	4⅝	...
200,000l	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —106	103 —106	105	103
250,000l	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106		
88,321	West India and Panama Telegraph, Limited	10	2⅞— 3⅛	2⅞— 3	3⅛	2 15/16
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11¼— 11⅝	11¼— 11⅝	11⅝	11½
4,669	Do. do. do, 6 p. c. 2nd Preference ...	10	11 — 12	11 — 12		
1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	120 —125	120 —125		
175,100	Do. do. 6 p. c. Sterling Bonds	100	99 —103	99 —103		
42,853	*Westmstr. Elec. Sup. Corp., Ord., Nos. 101 to 42,953 (£3 only paid)	5	2⅛— 2⅜	2⅛— 2⅜		

* Subject to Founders Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7⅛—7⅜.—Elmore Copper Depositing Priorities, 7 —7⅛.—Elmore's French Patent Copper Depositing shares of £2 (issued at 10s. premium, £1 10s. paid, including premium), 2—2⅛.—House-to-House Company (£5 paid), 4⅜—5⅛.—London Electric Supply Corporation, Ordinary (£5 paid), 1⅞—2⅛.—Manchester Edison and Swan Company, £9 (£1 paid) 11/- —13/-.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), 2⅛—⅜.—Preference, 4⅛—4⅜.

BANK RATE OF DISCOUNT.—6 per cent. (7th November 1890).

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

(*Continued from page* 653.)

Fig.	Position of binding screws.	State of nut and screw T.	Length of lug in inches.	Current in ampères	P.D. in volts.	Resistance in ohms.
7	A and D	...	...	8	0·00187	0·000230
	A and C	...	3·25	8	0·00117	0·000150
	A and B	...	1·5	8	0·00060	0·000070
	T and A	Dirty / Clean	Wire pressed on at T	8 / 8	0·00038 / 0·00028	0·000047 / 0·000035
		Dirty / Clean	Wire screwed on at T	8 / 8	0·00028 / 0·00025	0·000035 / 0·000031
8	E and H	...	6·5	8	0·00219	0·000270
	F and H	...	4·0	8	0·00126	0·000160
	G and H	...	1·5	8	0·00049	0·000060
	T and H	Dirty / Clean	...	8	0·00021	0·000030
				8	0·00021	0·000030
9	K and L	Dirty	...	8	0·00522	0·000650
	T and O	Dirty / Clean	...	8	0·00063	0·000080
			...	8	0·00057	0·000070
	K and L	Very dirty	13	5	0·00500	0·001000
	T and O	very dirty / Clean	...	3	0·00524	0·001750
			...	10	0·00044	0·000044

From this it appears that the resistance per inch of the lug alone is about 0·000043 ohm; and that the resistance at the contact of two lugs which were tightly screwed together when quite clean, but which have become very dirty from the acid spray falling on them, may be as high as 0·001 ohm, or thirty times the resistance of an inch of the lug itself. The resistance between T and O, fig. 9, being greater than between K and L, when T was very dirty, is probably explained by the fact that when the wire was screwed under T to test the resistance between T and O, fig. 9, it was screwed against an exceptionally dirty bit of the lug.

As we have shown in the Edinburgh paper, the mean resistance from positive lug to negative lug of one of these accumulators *complete* is about 0·004 ohm when the contacts between the lugs and the testing wires are made quite clean. Hence it appears that about one-seventh of the whole mean resistance of such an accumulator is caused by the resistance of the lead lugs themselves; and that the resistance of such accumulators as we have been experimenting with can, when joined up in series, be increased by 25 per cent. if the contacts be allowed to become dirty by the acid spray falling on them, even although they remain all tightly screwed up.

Since these tests were made we have had all the accumulators disconnected, the contacts carefully cleaned and tightly screwed up, and the nuts and screws then coated with hot paraffin wax.

The coarsely divided paraffined cork which is sold by Messrs. Drake & Gorham for floating on the tops of accumulators to filter the hydrogen gas from sulphuric acid spray, was most successful in stopping the acid fumes from escaping into the room when we first obtained it. As, however, the cork became thoroughly wetted with the liquid, its filtering property was much diminished. It appears to us that there still remains the need for a really good spray arrester.

IV.

Analysis of Plugs.

The following is the report of the analyses of the plugs removed at different stages of the charging and discharging, which Mr. Robertson has been so kind as to prepare for us:—

Report by G. H. Robertson on Analyses of Plugs from an E.P.S. Cell made in the Chemical Department of the Central Institution.

16th October, 1890.

Preparation of the samples for analysis:—

The positive samples were taken separately, washed on to filters, and thoroughly freed from acid. In every case the samples from the bottom were harder to wash than the others, and the residues were dried for some hours at about 120° C.

The samples were now ground up fine in an agate mortar, and the splinters of wood and glass removed as far as possible. The approximate weights for analysis were now taken and re-dried on watch glasses at about 140° C.

At first the substance for analysis was dissolved in a porcelain dish, and the insoluble residue of sulphate was filtered off with the intention of determining the amount of sulphate by the ammonium acetate method; but owing to the small amount of material available and the error introduced by the solubility of lead sulphate in the nitric acid used to dissolve the sample, the attempt to determine both the peroxide and the sulphate was abandoned and the samples were used to determine the peroxide only as accurately as possible. This course was justified by the fact that very careful qualitative experiments showed that nothing but peroxide and sulphate was present in the plugs.

The method employed to determine the peroxide was the ammonium oxalate and permanganate method described in Sutton's "Volumetric Analysis," as in previous analyses it had been found very sensitive; and the solutions were checked about every two days against pure lead peroxide, and each day the solutions were run against each other, but they were not found to alter practically in the time they lasted. The first lot of ammonium oxalate was standardised against permanganate which had been very accurately standardised against iron, and by the nitrometer method.

Using this solution, "pure" lead peroxide, as purchased, and which afforded a slight white residue like silica, contained 97·3 per cent. as the mean of a large number of analyses made with different weights; and any subsequent solution which gave the percentage between 97·2 and 97·5, inclusive, was taken as correct. It will be noticed that D and A′ gave practically the same percentage as the sample of pure lead peroxide.

The residues from the samples containing the highest percentage of peroxide of lead were white, those from the samples containing the smaller percentage were brownish-white; and it was noticed that if the larger grains were crushed under the end of a glass rod they had a dark centre of peroxide, which at once dissolved, leaving a slight yellowish-white insoluble ring. By grinding the sample very fine in the mortar, so as to break up the capsules of sulphate more thoroughly, the residue was got lighter in colour; and using a flask to boil the substance in, the residue becomes perfectly white: but this yellowish-brown tinge to the sulphate does not seem to be due to any appreciable quantity of undissolved peroxide, as practically identical percentages were obtained with pure white and yellowish residues. Dark residues gave low results.

In the case of the very hard plugs, there was some error from the glass and wood, which could not be picked out altogether, though the samples were picked over very carefully (*cf.* D′, E′).

Lead Peroxide Formed on the Positive Plates during Charge.

Percentage of PbO_2	Mean.		Mean increase in percentage PbO_2 and time interval.	Total Hours Charge.	P.D. in volts just		Specific Gravity of Liquid.
					Before breaking circuit.	After closing circuit.	
A*				H. M.			
Top ... 30·6 / 31·0 / 32·7	31·43						
Middle 35·23 / 35·34	35·28	34·5*		0 37	2·134	2·122	1·178
Bottom 36·5 / 37·3 / 36·6	36·80						
			41·0* H.M. 9 11				
B							
Top ... 77·0	77·00						
Middle 76·1 / 76·8	76·45	75·5		9 48	2·2	2·186	1·198
Bottom 73·2 / 73·3	73·25						
			8·8 1 49				
C							
Top ... 88·0	88·00						
Middle 85·15 / 84·72	84·93	84·3		11 37	2·234	2·186	1·201
Bottom 79·8 / 80·3	80·05						
			10·8 2 50				
D							
Top ... 96·3 / 96·8	96·5						
Middle 94·1 / 93·42	93·76	95·1		14 27	2·4	...	1·206
Bottom 95·00 / 95·11	95·05						

* Only the surface of the positive plugs was removed in the first attempt, A.

Lead Peroxide Reduced on the Positive Plates during Discharge.

Percentage of Pb_3O_4.	Mean.	Mean increase in percentage $Pb O_2$ and time interval.	Total hours discharge	P.D. in volts just		Specific gravity of liquid.
				Before breaking circuit.	After closing circuit.	
A′						
Top ... 96·7, 97·0	96·85					
			H. M.			
Middle 94·88, 94·37	94·62	94·9	0 25	1·998	2·002	1·205
Bottom 93·4, 93·1	93·25					
		H. M.				
		31·7 7 27				
B′						
Top ... 67·5, 67·06, 67·0	67·2					
Middle 64·82, 64·25	64·53	68·2	7 52	1·956	1·958	1·189
Bottom 57·9, 57·7	57·8					
		15·3 4 16				
C′						
Top ... 49·0, 48·8, 48·8, 48·3	48·7					
Middle 49·92, 50·5, 50·2	50·45	47·9	12 8	1·850	1·902	1·180
Bottom 44·07, 44·90	44·48					
		6·5 2 29				
D′						
Top ... 41·8, 44·01, 43·9	43·2					
Middle 42·70, 42·92	42·81	41·4	14 37	0·6	1·9	1·175
Bottom 37·9, 38·6	38·25					
		5·4 3 26				
E′						
Mixed 36·6, 36·7, 34·8	36.00		18 3	Zero E.M.F. indefinite on re-making circuit.		1·172

For the sake of comparison the percentage of $Pb O_2$ at A in the following table is taken as 47·9, as at C′.

The calculations refer to the mean values of $Pb O_2$, and the values of the P.D. before breaking circuit.

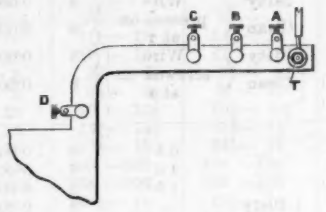
	Interval.	Increase per hour in percentage $Pb O_2$.	Percentage increase in P.D. in interval.	Percentage increase in $Pb O_2$ in interval.
Charge.	A to B	3·0	3·1	27·6
	B to C	4·8	1·6	8·8
	C to D	3·8	7·4	10·8
	Interval.	**Decrease per hour in percentage $Pb O_2$.**	**Percentage decrease in P.D. in interval.**	**Percentage decrease in $Pb O_2$ in interval.**
Discharge.	A′ to B′	4·3	3·1	31·7
	B′ to C′	3·6	5·4	15·3
	C′ to D′	2·6	67·4	6·5
	D′ to E′	1·6	100·0	5·4

The screening influence of lead sulphate is clearly brought out in this table. Between A and B the surface film and the coatings on the partially reduced granules of $Pb O_2$ are got rid of; then between B and C the pure lead sulphate is attacked; and finally, between C and D, with the removal of the last traces we get a very rapid rise in volts P.D.

In the case of the negative plates, the sulphate was in such a loose and powdery condition that it fell off and adhered to the insides of the bottles used for receiving the plugs in, and it was quite impossible to obtain representative samples for quantitative analysis; so qualitative tests had to be made, which in the case of charge, showed nothing but sulphate of lead and lead, the sulphate decreasing during charge until at D there was practically nothing but pure lead.

During discharge the sulphate increased; at C′ there was a doubtful indication of peroxide of lead, and at D′ and E′ there was decided evidence of peroxide. After a few days the plugs were white all over, and there was no difference in appearance between the front and back. The water had no acid reaction.

FIG. 7.



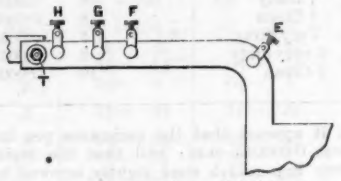


FIG. 8.

FIG. 9.

It will be observed that:—

(*a.*) The particles of the peroxide very soon get coated in the discharge with a layer of lead sulphate, which protects the peroxide from further action, as shown by the examination of the dark-coloured residues which contained peroxide, and which were rendered very hard to dissolve by the coating of sulphate.

(*b.*) The analysis also shows what a large proportion of active material is still remaining at the end of the discharge. This has been remarked on by many experimenters.

(*c.*) The loose powdery surface of the positive plate seems to be thoroughly converted into lead sulphate. C and D′ dissolved readily, leaving pure white residues.

(*d.*) When the peroxide in the surface of the plate falls to about 31 per cent. the cell loses its E.M.F. very rapidly, owing to the inactive layer of sulphate impeding the action of the sulphuric acid on the active material behind it, and also to the formation of peroxide on the negatives. The diffusivity of the acid is decreasing, and it has to penetrate further into the plate to find active material. When the whole of the paste approaches this composition of 31 per cent. peroxide, the cell loses its E.M.F. entirely.

(*e.*) The action seems to take place most rapidly where the current-density is greatest; the plate gets hard there from sulphate soonest on discharge, and oxidises quickest on charge.

Plantè and Messrs. Gladstone and Tribe have both noticed the formation of peroxide of lead on the negative plate during discharge, and pointed out that once it is formed more rapidly than it is reduced, the two plates must rapidly approach electrical equilibrium; that when the circuit is broken local action alone can take place, and this will reduce the peroxide on the negative plate, and on making the circuit again the cell will again give a current; and in this way Messrs. Gladstone and Tribe account for the resuscitating power of the cell, as well as for the rise of E.M.F. on breaking the discharging circuit.

I have to acknowledge the facilities afforded me for seeing the plugs as they were removed, and the care taken to let me have the samples in good condition.

I am also indebted to Professor Armstrong for his invaluable advice and assistance in the execution of the work.

G. H. ROBERTSON.

From the mean results of the preceding analysis carried out by Mr. Robertson, we have drawn the curves seen in the lower part of figs 1 and 2, and which show the percentage of $Pb O_2$ found in the plugs of the positive plates at all stages of the charge and discharge. In the $Pb O_2$ curve for charge the first point is obtained from the analysis of the plugs at the end of the normal discharge —that is, when the terminal P.D. had fallen to 1·85 volts, indicated by the point c′ in fig 2. The percentage of $Pb O_2$ actually found in the positive plugs at the point indicated by A (fig. 1) does not lie on the $Pb O_2$ curve as drawn, but, as already indicated, this arises from the specimens removed from the plugs at experiment A being only scrapings off the surface, and therefore not representing the average constitution of the plugs. On all subsequent occasions when specimens were removed from the plates, whole plugs, as already stated, were detached. The analysis at the point A (fig. 1) was, therefore, abnormal, and the percentage of $Pb O_2$ obtained for this point, and which is given in the table, is not indicated on the curve.

If the energy given out by the cell be produced by the conversion of $Pb O_2$ in the positive plugs, and of Pb in the negative, into lead sulphate, a constant value of the P.D. at the terminals of the cell when a constant current is passing through it ought to correspond with a constant rate of variation of the percentage of $Pb O_2$ in the positive plugs; so that for a constant current

$$\text{the terminal P.D. should} \propto \frac{d\,(Pb\,O_2)}{d\,t},$$

t representing time. This connection is seen to exist fairly well in the case of the discharge where the slope of the $Pb O_2$ curve is roughly constant as long as the P.D. is constant, and acquires a less inclination to the axis of time when the P.D. is rapidly falling. In the case of the charge, the connection between the value of the P.D. and the slope of the $Pb O_2$ curve is not so easily seen; but this arises from the fact that towards the end of the charging there is a rapid rise in the resistance of a cell, and therefore in the P.D. required to send a constant current through it; further, the back E.M.F. steadily increases during charging on account of the polarisation, which grows larger and larger from the continuous evolution of gas at the surface of the plates.

(To be continued.)

NEW PATENTS—1890.

17580. "Improvements in the decorative arrangement of electric lights." J. M. M. MUNRO. Dated November 3.

17589. "Improved means for lighting street gas lamps by electric spark." C. BARNETT. Dated November 3.

17600. "An electrical switch for opening and closing of circuits, switching on currents, and so forth." A. C. LAINCHBURY. Dated November 3.

17611. "Improved electrical push-button for signalling circuits." C. D. ABEL. (Communicated by H. Messing, Germany.) Dated November 3.

17631. "Improvements in or relating to electric accumulators." P. LAUBER. Dated November 3.

17674. "Incandescent gas lights." C. M. LUNGREN. Dated November 4. (*Complete.*)

17690. "Method of and apparatus for obtaining electricity by hydraulic power." C. A. RANDALL. Dated December 4.

17711. "Improvements in means for the distribution of electricity." H. EDMUNDS. Dated November 4.

17716. "Improvements in and relating to machines for covering wire." H. H. LAKE. (Communicated by the New England Butt Company, United States.) Dated November 4. (*Complete.*)

17728. "Improvements in electric railways." M. W. DEWEY. Dated November 4. (*Complete.*)

17829. "Improvement in incandescent lampholders or suspenders." J. E. CHARNOCK. (Communicated by C. Charnock, Russia.) Dated November 6.

17851. "Improvements in electric thermostats for ships' bunkers, refrigerating rooms, and other purposes." H. BINKO. Dated November 6.

17852. "Improvements in magneto generators for signalling or medical purposes." H. BINKO. Dated November 6.

17861. "Improvements in the manufacture of electrical conductors and electrodes, and for connecting them, and for analogous purposes." J. MARX. Dated November 6.

17863. "Improvements in portable electric lamps." M. P. HARDT. Dated November 6.

17899. "An improved self-locking electric switch." W. LOWNDS, E. EMANUEL and J. WOOD. Dated November 7.

17905. "An induction transformer coil, and methods of using the same for telephone call bells and other purposes." C. T. B. BRAIN. Dated November 7.

17912. "An electricity meter." J. T. BOTTOMLEY. Dated November 7.

17919. "Improvements in electric energy meters." R. J. F. MOSTYN. Dated November 7.

17929. "Improvements in or connected with armatures for dynamo-electric machines." B. REJCHMAN. Dated November 7.

17937. "Improvements in and relating to electric lamps or lighting apparatus." F. V. MAQUAIRE. Dated November 7.

17940. "Improvements in arc lamps." SIEMENS BROTHERS AND CO., LTD. (Communicated by Siemens and Halske, Germany.) Dated November 7.

17941. "Improved means for charging accumulator batteries on electric circuits supplied by current generators." SIEMENS BROTHERS & CO., LTD. (Communicated by Siemens & Halske, Germany.) Dated November 7.

17951. "Improvements in electric switches." H. H. LAKE. (Communicated by F. C. Jenkins, Germany.) Dated November 7.

17954. "Improvements in electrical accumulators or storage batteries." H. L. MAUGRAS. Dated November 7.

17976. "Improvements in means for firing ordnance charges by electricity." G. QUICK. Dated November 8.

17987. "Improvements in electro-medical appliances." W. R. VARNEY. Dated November 8.

18034. "An improved electric switch." G. F. REDFERN. (Communicated by A. Schirner, Germany.) Dated November 8. (*Complete.*)

18076. "Improvements in sockets or holders for incandescent lamps." J. Y. JOHNSON. (Communicated by J. W. Collier, United States.) (*Complete.*) Dated November 10.

18088. "Apparatus to be employed at telephonic switchboards." J. E. KINGSBURY. (Communicated by The Western Electric Company, United States.) Dated November 10.

18103. "Improvements in electric switches." C. E. KNOWLES. Dated November 11.

18158. "An improved electric pressure indicator." C. H. GRAY. Dated November 11.

18163. "An appliance for the administration of electricity to the human body in Turkish baths." M. HUMM. Dated November 11.

18186. "Improvements in electrical measuring instruments." H. H. LAKE. (Communicated by E. Weston, United States.) Dated November 11. (*Complete.*)

18195. "Improvements in telephonic apparatus for minimising or overcoming inductive and other undesired electrical disturbances in telephonic circuits." A. E. COTTERELL. Dated November 11.

18206. "Improved commutator for dynamo-electric generators and motors." H. DAVIS and A. H. STOKES. Dated November 12.

18217. "Improved protector for telegraph, telephone and other electric instruments." D. MACLEAN. Dated November 12.

18220. "Improvements in connecting electric lamps and apparatus to leads." W. ALLEN and O. V. THOMAS. Dated November 12.

18247. "Improvements in fittings for electric lamps and their conductors." J. D. F. ANDREWS. Dated November 12. (*Complete.*)

18266. "Improvements in electric tramways and electric conduits." H. J. DAVIES and L. B. S. DUTSON. Dated November 13. (*Complete.*)

18292. Improvements in switches for electrical purposes." B. M. DRAKE and J. M. GORHAM. Dated November 13. (*Complete.*)

18409. "The improvement of electrical switches and other electrical apparatus." L. A. DAVIES. Dated November 15.

18412. "Improvements in electric batteries and lighters for cigars and other purposes." D. ROBERTSON. Dated November 15. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS 1890.

350. "Improvements in the formation of electrodes for use in primary and secondary electric batteries." L. EPSTEIN. Dated January 8. 8d. Consists in dividing the process of manufacturing the electrodes into two separate parts, the first part being limited to the making of so-called raw electrodes, which are then transformed into positive electrodes, with the assistance of an electric current in an electrolyte, containing either diluted sulphuric acid, or a suitable salt of sulphuric acid, while the negative electrodes are formed by a reduction of the positive electrodes. 7 claims.

2199. "Improvements in cores and armatures for electromagnets, solenoids, and the like." S. C. C. CURRIE. Dated February 11. 4d. Consists, firstly, in providing a core or armature of a compact mass of iron in granular form, such as iron chips, filings, or shavings, as described; consists, secondly, of a core or armature formed by mixing or combining with iron filings, chips, or shavings, an insulating substance or material in a granular or liquid condition, and then causing the same, after being subjected to pressure and drying, to assume a compact mass; and consists, thirdly, of a core or armature formed by mixing or combining with iron filings, chips, or shavings, an insulating substance or material as silicate of soda, in a granulated or finely divided state or condition. 10 claims.

2234. "Improvements in electro-mechanical movements, chiefly designed for regulating the carbons in electric arc lamps, and for similar purposes." S. E. NUTTING. Dated February 11. 8d. The object of this invention is to make an electro-mechanical

movement that will be proportioned at all times and under all circumstances to the quantity of the electric current, varying with every variation in the quantity of such current. 5 claims.

2464. "Improvements in electric light fittings." C. M. DORMAN and R. A. SMITH. Dated February 15. 6d. Consists partly of forming the metallic terminals of the lampholder and ceiling plate with a projecting hook round which the wire conveying current can be twisted; the weight of the fitting is then borne by these hooks instead of by the terminal screws. Also consists in using a novel form of spiral spring nut by which the reflector or shade is held on to the lampholder. Also consists in forming an independent cord-grip arrangement in the cover of the ceiling plate, consisting of a screwed nozzle through which the wires pass, which nozzle, when screwed home, squeezes the wires, which are led one on each side of a loose disc between the nozzle and the cover of the ceiling plate. 5 claims.

2621. "Improvements in electrically driven fans." H. G. WATEL. Dated February 18. 6d. Consists in applying the electrical driving near the centre of the fan, accommodating the electro-dynamic apparatus within a hollow boss. 1 claim.

2825. "Improvements in bases, covers, and fixings for electrical safety fuses, switches, and the like." W. WHITE. Dated February 21. 6d. Relates to means of making attachments and fixings to ceramic material.

2957. "Improvements in electric counters or apparatus for ascertaining and registering the duration of the passage of an electric current." J. J. A. AUBERT. Dated February 24. 6d. Consists of a clockwork movement, the pendulum of which is governed by an electro-magnet or a solenoid, which is in communication with the conductor of electricity. When the current passes, the clockwork movement is put in motion, but when the current is interrupted the pendulum encounters an obstacle which stops the clockwork. If the face of the clockwork is provided with a suitable scale and pointers, the exact time during which an electric current has passed will thus be registered. 3 claims.

3024. "Improvements in electric-motors." H. H. LAKE. (Communicated from abroad by E. B. Parkhurst, of America.) Dated February 25. 11d. Comprises multiple magnets or coils in the field and armature, one or both of which are revolved, and groups of magnets or coils in the armature are successively caused to act in conjunction with groups of magnets or coils in the field, when the respective poles of the groups of magnets or coils are so related to each other as to produce a maximum result from the current employed. 7 claims.

3924. "Improvements in electric Batteries." H. H. LAKE. (Communicated from abroad by the Crosby Electric Company, of New York.) Dated March 12. 6d. Consists in certain novel features, the object being to produce a simpler, cheaper, and more effective device than is now in ordinary use. 4 claims.

THE FRENCH TELEGRAPH AND TELEPHONE BUDGET.

THE discussion on the above portion of the French Budget was sufficiently acrimonious, but if possible our Parisian contemporaries' comments were more so. To take one, for instance: The discussion on the Budget of Posts and Telegraphs permitted the Chamber to clearly manifest its approbation for the system set forth by M. de Lanessan and some others, a system which consists in treating the postal service as a well administered service, that is to say, in reserving a small portion of its profits to improve the position of its staff and develop its material, in obedience to the growing requirements of the traffic. From the new studies to which the Government and the Budget Commission have undertaken, a new scheme has come forth, which the commission defends to-day before the Chamber, and which increases by 2,200,000 francs in receipts and expenses the postal budget of 1891. The 2,200,000 francs of expenses are composed as follows: At Paris, creation of two new offices and the employment of 100 postmen; and for the departments, among other things, the creation of 100 *petits télégraphistes*, unification of the kilometric indemnity of telegraph messengers to 7¼ centimes; creation of telegraph offices, prolongation of the daily service in 13 offices, the establishment of 1,000 kilomètres of new wire, and an increase of 1,415,000 francs in the payment of the staff. But the sum of 2,200,000 francs only applies to the year 1891. The Minister himself declares that in order to carry out the programme of improvements necessary, much greater expenses will have to be met. He will set them forth in the budget project for 1892, which will shortly be laid on the table. Where are the 2,200,000 francs to be found for 1891? The Government and the commission propose to find them as follows: In the first place, they alter Article 6 of the law of April 5th, 1879, so as to place a tax of 0·10 on valuables of all kinds confided to the Post Office for recovery and remaining unpaid. Then they alter Article 5 of the law of April 6th, 1878, in such a way as to raise by 0·1 the tax on all printed matter over 20 grammes (other than electoral circulars, voting bulletins, newspapers, and periodical publications). The tax would thus be 0·02 up to 5 grammes, 0·03 from 5 to 10 grammes, 0·04 from 10 to 15 grammes, 0·05 from 15 to 50 grammes. To these proposals two amendments were presented. M. Mir asked that the expense should be raised to 2,500,000 francs, so that 300,000 francs might be given to the ambulant service.

M. Leydet wished to have the expenses raised to 3,000,000 francs, thus providing 300,000 francs for the ambulants, 100,000 francs for the principal receiving office, and 400,000 francs for the Parisian Telegraphic Service. But the authors of the amendments, while increasing the expenses, do not approve the measures proposed for the receipts. They regarded them as new taxes, and fatal on industry and commerce. It was from the profits of the working that they wished to deduct the cost of the improvements. M. Peytral, on the other hand, contended that before voting increased expenses, it would be necessary to ratify the increase of the correlative receipts. This objection, however, did not hold, and the President of the Budget Commission easily defeated it, because, at all times, Parliaments have voted public expenses before establishing taxes to meet them. On the contrary, the State determines its needs before knowing its resources. The Mir and Peytral amendments were rejected by 316 votes against 182 votes, and the expenses proposition of the Commission adopted. An amendment by M. Poulié, proposing an increase of 20,000 francs for the transformation of some single offices into compound, was also rejected. Regarding Corsica, M. de Douville-Maillefen informed us that while the postal service between Dover and Calais worked admirably for 100,000 francs per year, that between Nice and Corsica cost 350,000 francs, and worked when it pleased the concessionaires.

The Telephone Budget was voted without any observations of interest.

CORRESPONDENCE.

Electro-Deposition of Copper: Misconceptions and Fundamental Laws.

I notice that your contemporary, the New York *Electrical Engineer*, in its issue of the 12th ult., gives a leader in which it professes to "set at rights" certain "obvious miscalculations" put forward editorially in your paper. Without particularly referring to the degree of success with which its proposed task has been accomplished, I may perhaps be allowed to say, generally, that the article in question, and also certain passages in your own correspondence columns, suggest the prevalence of misconceptions which may perhaps be entirely removable by a simple reference to some of the fundamental laws of electrolysis.

One of these misconceptions (a) is that it is not permissible to assume, in the abstract consideration of a given case of electro-deposition, that the operation is carried on in one tank, instead of in several or many tanks, having in the aggregate the same extent of anode and cathode surface.

Another misconception (b) is that it is unjustifiable, because necessarily unfair and detrimental to a process for the electro-deposition of copper, to assume in a given case that the action takes place under a potential difference of one volt.

A third misconception (a_1), which is involved in (a),

is that a current of (say) 3,000 ampères, depositing a given mass of copper in a given time, must necessarily give a result superior in point of economy to that obtained with a current of (say) 110,625 ampères depositing the same mass of copper in the same time.

It would, of course, be a very grave misconception to suppose that any results at variance with the well-understood fundamental laws and quantitative data of electrolysis can be obtained in practice.

The fundamental expression for electrical energy or work is

$$Q\,E,$$

in which Q is quantity of electricity and E electromotive force.

To dissolve and to deposit electrolytically a given mass of copper, some amount of electrical energy is required, and must be expended in performing electrical work. This amount of energy, however, is variable within wide limits. The main object of the art of electro-deposition is to determine in practice what amount of electrical energy it is most profitable to expend in producing a given result, *e.g.*, in depositing the given mass of copper.

The above expression for electrical energy may conveniently be rendered as

$$C\,E\,\theta,$$

in which C is current and θ time.

Now although this value, as a whole, bears no definite relation to a given mass of (say) copper to be deposited, it involves one product, viz., $C\,\theta = Q$, which, in the case of one depositing cell or tank, or any number of cells or tanks in parallel, is absolutely definite and constant in relation to the given mass. This fact is expressed in the statement that if $C = 1$ ampère, and $\theta = 1$ second, the mass of copper deposited will be neither more nor less than ·0050478 grain.

It may here be observed that, in circuits containing no counter-electromotive force, the above value, $C\,E\,\theta$, may be equated to :

$$C^2\,R\,\theta = \frac{E^2}{R}\,\theta,$$

where R is the resistance of the circuit.

But, in the contrary case, when E is opposed by a back electromotive force, E_1, the total energy expended is expressed by $C\,E\,\theta$, whilst $C^2\,R\,\theta$ represents the energy converted into heat, and $C\,E\,\theta - C^2\,R\,\theta = C\,E_1\,\theta = \frac{E_1^2}{R_1}\,\theta$ (where R_1 is the resistance associated with E_1), represents the energy rendered potential in the products of the electrolysis. And it may further be observed that in the case of copper dissolved from and deposited upon copper, the back E.M.F. is so inconsiderable, at least when electro-deposition takes place under a potential difference approaching 1 volt, that the circuit may, practically, be considered as one in which

$$C\,E\,\theta = C^2\,R\,\theta = \frac{E^2}{R}\,\theta.$$

Now, suppose we have to consider a given case of electro-deposition in the abstract—to obtain some idea of the power, time and *matériel* which would be requisite to carry it into effect, under conditions susceptible of being modified according to the requirements of practice ; the first thing we have to do is to determine the value $C\,\theta = Q$, which is dependent solely upon the nature and upon the mass, or weight, of metal to be dissolved and deposited. If *time* be given or assumed, we have only to calculate C from the datum given above. Now C is the current necessary to deposit, in the time θ, the given weight of metal in *one* depositing cell or tank. Technically, this expression may mean any number (n) of tanks, provided they are connected, not in series, but in parallel. Of course we are bound to assume the simplest conditions ; nor is it necessary, as I will now show, to assume any other. If, instead of one cell or tank, there be n cells or tanks in parallel, these cells being similar to each other, and equivalent in the aggregate to the single cell assumed, then, of course, the current through any one of these will be $c = \frac{C}{n}$ or $n\,c = C$. And if the n cells be arranged in series, exactly the same conditions will prevail ; the current in any one of them will be $c = \frac{C}{n}$. In a concrete case this statement would not be accurate, because the dynamo giving the current would be constructed with a certain resistance, and to give a certain E.M.F. In such a case, it might be advantageous to arrange the tanks in multiple arc, or to connect them in series. M. Gramme, in his well-known experiments, found it advantageous to connect the tanks in series, simply because the dynamo he used was not one of low resistance. In our abstract consideration we are not tied, so far, to any stated E.M.F., or resistance outside of the depositing tanks ; and it is absolutely indifferent, therefore, whether we determine to connect the tanks in parallel or in series. We can now obtain dynamos of very low resistance and economical in working, which was not the case at the period of M. Gramme's experiments. But even if this were not the case, it is not only allowable to assume the simplest conditions—that of a real or suppositious single tank—but it is not permissible to do otherwise in the absence of concrete data. Only an outsider would suppose for a moment that our data in relation to a single tank, from which other data can readily be obtained, were intended to imply, in case of extended operations, the construction of an enormous reservoir.

Our next step, to enable us to determine the energy to be expended in depositing the given mass of metal, is to fix a value for E. This value, in our abstract view, should be the potential difference of the electrodes in a single cell. Note that we have already determined C, which is the *ratio* of E to R. If in our equation we over-estimate E, from the point of view of economical working, we also in this equation over-estimate R. Thus, before anyone can fairly complain that too high a value has been assumed for E, he must have arrived at the conclusion that the corresponding value for tank resistance (R), viz., $\frac{E^2\,\theta}{W} = \frac{W}{C^2\,\theta}$, is too high for economical working, and that more capital should be invested in tank plant, and less money expended in electrical energy, than are indicated in the equation arrived at. In the case of a process in which the strong point is low tank resistance, a high value of E and of R might advantageously be challenged on the score of economy ; but when the weak point of a process is high tank resistance (*vide* the penultimate paragraph in my letter on page 572), the suggestion of a high value for E might be unfair only in the sense of unduly favouring the process in question.

Having arrived at a value, $W = C\,E\,\theta$, applicable in the case of a single tank, or in that of the equivalent n tanks in parallel, we have data so readily applicable to the case in which the n tanks are in series that it is not necessary in general to specially refer to this case. The resistance of the "single tank" being R, that of each of the n tanks will of course be n R, and that of the n tanks in series will be n^2 R. Now to obtain the original current passing between unit anode and cathode surface, we require a potential difference equal to E acting over each tank, or n E for the n tanks in series. This current will obviously be $c = \frac{n\,E}{n^2\,R} = \frac{E}{n\,R}$, and the electrical energy expended in the time θ will be $n\,E \times \frac{E}{n\,R}\,\theta = \frac{E^2}{R}\,\theta = C\,E\,\theta$, as before. To assume that there is essentially any advantage in reducing the current from C to $\frac{C}{n}$, when the electromotive force is augmented from E to n E, and that the mere indication of this reduction of the current is a crushing rejoinder to those who may calculate current on the "single tank" basis is a misconception, that to be refuted needs only to be pointed out.

Desmond G. FitzGerald.

Telephone and Telegraph Construction—A Pole for Many Angles.

As I have not seen nor heard during my 20 years' experience in telegraph construction of a really good improvement in the arming of poles for positions where the angles, acute or obtuse, cannot easily be avoided, I beg to submit a rough sketch of a novel arrangement which may be useful to, and improved by, electrical engineers.

The objects and advantages are as follows, viz. :—

1. To dispense with G.P. cross connections and to admit of the line wires being run through in a similar manner to the ordinary poles.
2. To lessen complications on terminal poles.
3. To suit all, or many, angles by simply fitting the arms on the iron supports to face the pole on each side of the span.
4. To keep the wires the same distance apart as the holes in the arms, and thereby lessen the risk of contacts in stormy weather, &c.

A square pole, or two round poles fitted together in the form of the letter A or H, might be employed to

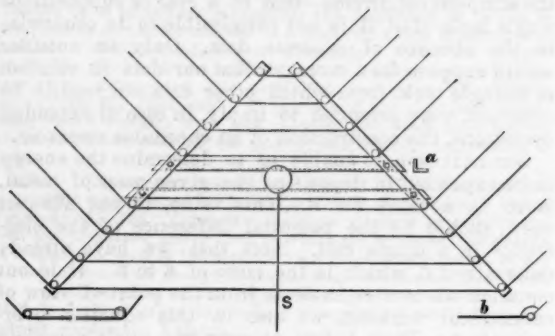


FIG. 3. FIG. 1. FIG. 2.

Scal ½ in. = 1 foot.

a, Section of iron ; *b*, Thick wire to act as stay ; S, Stay.

advantage in exposed positions. It would be advisable to terminate all the wires as shown by fig. 2 (the groove will admit of this in many cases) on account of the undue strain at the insulators, and to have two inner wires at both ends of the arms of a larger gauge to act as a brace ; or the arrangement shown by fig. 3 might be preferable.

When the pole is to act as a terminal pole the arms would of course be braced together in a similar manner to fig. 2, but, say, under the shoulder of the insulator bolt.

I will say nothing about staying, but simply show *a* stay.

A. I. E. E.

November 26th, 1890.

Improvements in Telephone Switchboards.

With your permission I will reply to the letter of the Telegraph Manufacturing Company in yesterday's REVIEW.

In my communication which you published on October 31st, I showed that the advantages claimed, including the supposed saving of 30 per cent. in operating, did not exist, but that on the contrary there was a loss, though I did not presume to define it in percentages, the careless use of which on mere estimates should be discouraged. But recognising, as I do, the many considerations which may determine the type of switchboard to be adopted, I assumed there might be some advantages not stated in the original article. In the letter now under reply, those advantages are stated to be accessibility for adjustment and repair, and certainty of action of the indicator drops.

The most delicate parts of a switchboard are the indicator drops. The illustrations on page 488 (October 24th) show the drops in front with three rows of plugs behind them. The back view (fig. 2) shows the cords between the mechanic and the drops. In the board shown in my article the drops are within a few inches of the mechanic, and there is no obstruction whatever in the way. In this respect, therefore, the exact contrary must be read. The "improved" boards in the most vital part are not more accessible, but less so. But too much importance must not be attached to this. The inaccessibility is not a serious drawback ; it might well be submitted to if an increase in facility of operating is thereby attained, but there is no such increased facility.

The "certainty of action of the indicator drops" must be limited by the remarks in the original description, in which it was stated that they were "found to act perfectly well for all telephone lines of ordinary length"—a limitation which is not usually considered an advantage, any more than a reduction of their sensitiveness contributes to increasing the certainty of their action.

The letter further says that I have fallen into the error of assuming that the board shown is the only pattern made. That is not so. The description stated that the board was a standard pattern for any number of lines from 25 up to 150. I took this to mean that an exchange starting with 25 lines would put in a 30-line board, which would form a convenient unit for additions up to 150. This meaning appears clearly from my words, "by the time the exchange had reached." I see that the words in the original description are capable of another reading, but my error arises from having reasonable conditions in mind. The modification changes the ground, but, unfortunately, this is one of those subjects which will not permit one to change one's ground without encountering a further set of conditions for consideration. A unit of 30 is small, but one of 150 is larger than is generally considered economical for small exchanges. To add smaller boards which do not match the first does not commend itself, and to change complete switchboards of small number for complete switchboards of a larger number as the subscribers increase, though possible to large companies with a number of exchanges, is expensive, and more serious to smaller companies whose exchanges are limited in number, or distant from each other.

Then the letter states that if the small pattern annunciators are adopted, "the s. c. board will be quite as compact" as that illustrated in my article. I enclose photograph of several "s. c. boards," on inspection of which you will doubtless appreciate the remark I made, but which the Telegraph Manufacturing Company overlook. I wrote : "I would like to point out that it is not necessary to cover so large a space. The boards may be more compressed, but then the plugs are crowded. It is a choice of evils." The photograph shows 50-line boards of the same width as the 100-line board illustrated October 31st, except that the framework is narrower, they are thus about one-half as compact. To appreciate what equal compactness means, it is only necessary to refer to the illustration, page 523 (October 31st), and add to the 40 plugs there shown 60 other plugs.

I do not see that there is any necessity to "assume" the correctness of the lists of movements I gave. Mine is correct. The other is taken verbatim from the full description of the "improved" board. Comparison is made between the similar number of movements on the one board with speaking keys, and the other without, as if there were still some advantage in that. But it is the absence of these keys (or their equivalent) which is the cause of the clumsy working which I pointed out. More especially is this the case when the operations are carried beyond the mere connecting and disconnecting, which is as far as the comparison has yet gone. The extra plugs and their attachments which become necessary on the "improved" board (which works badly) are more expensive in first cost and maintenance than the speaking keys on the other board (which works well).

Then, with regard to the single-cord boards with speaking keys, allowing four movements in all, which are compared with the board giving seven movements. The Exchanges at Dewsbury and Greenock since August, 1888, and Blackburn since March, 1889 (I

omit instances of earlier date in other countries), have been provided with single-cord boards necessitating only four movements. The principle is well known to telephone engineers, and has been the subject of very able criticisms and reports, which have been published. A 200-line board is about 6 feet long. I am not aware that any other than multiple boards have been made upon this plan, but as the greater includes the less, it could be done if it were considered desirable. Taking the basis of equal compactness with the board on page 523, it is only necessary to add 60 more plugs to the 40 that are there, and 80 more speaking keys (or their equivalent) to the 20 that are there, and one of the reasons why it has not been done may become apparent. Supposing such a board to be made, what becomes of the simplicity and accessibility, not to mention economy, which are rightly (within reason) taken as desirable attributes of switchboards for small exchanges?

It would be affectation for me to overlook that some inference is intended to be conveyed by the reference to my communication as "criticisms by the Western Electric Company through Mr. Kingsbury." If it is intended to be implied that I sent to you, under my own name, a communication which had been prepared by others, you will perhaps permit me to say that the implication is both incorrect and unnecessary.

I am not authorised to criticise on behalf of my company, nor do I wish my remarks to bear the importance which the well-known experience of the Western Electric Company gives to their opinions on this and kindred subjects. I may say further that, in sending you a communication on a subject of general interest, it was not my intention either to advertise my own Company's manufactures or decry those of others. I have throughout confined my criticisms to the particular type of board described on October 24th, which may be manufactured by anybody who cares to take the responsibility of recommending its use, or whose customers in possession of all the information on the subject prefer to have it.

Descriptions communicated to the press are open to public criticism, and the area of critics should include all who can contribute useful information. To criticise on frivolous grounds is objectionable, but in glaring instances of a misleading character, it becomes a duty, especially so in the case of a subject which needs something more than superficial observation. Since the publication of the Telegraph Manufacturing Company's letter, there is no room for doubt that my criticisms were fair and accurate, in which case their origin, though it was frankly stated, is not material.

I do not know that I should have troubled you with those criticisms, but for the fact that I found the enduring work of far-sighted pioneers (some of whom are friends of mine) slightingly referred to in comparison with a supposed improvement, the claims of which I examined. I thought the result of my examination of sufficient interest to send to you.

I am sorry this letter is so long. Unfortunately, it takes a long letter to correct the errors of statement and suggestion which may be crowded into a short one.

J. E. Kingsbury.

November 29th, 1890.

P.S.—Will you kindly note I have reverted to the original title. I do so because there are single cord boards and single cord boards.

Electric Light on Shipboard.

It must be gratifying to electrical engineers engaged in ship-lighting work to find that the matter is receiving the attention of the Institute of London Underwriters, and other authorities. It must be admitted by those engaged in the work that it was high time some uniform rules or regulations on the subject existed, and also that electric light installations on shipboard should come under survey and inspection; cheap and nasty installations would then be the exception instead of being almost the rule they are at present; and this survey or inspection should not only be made on the completion of the installation but also at intervals thereafter. It is quite commonly the case to find some years after a ship has been fitted out that numbers of the lights have been shifted, new branches have been made in the wires, old ones left in connection, fuses rendered useless, being connected across by heavy wires and so on. These changes are mostly made by the engineers on board without the assistance or advice of any skilled electrician; consequently sometimes faults are introduced into what was at first a good installation. The inspection of all the fuses on board and of any new wires run in, or old ones disused, should be made frequently.

It seems to be imagined that the single-wire system is more likely to influence the compasses than the double-wire system: quite naturally one would think so, but practically it is such an easy matter to avoid any action on the compasses, that there in reality can be no preference for the one system over the other on that score. The compasses are fixed in certain positions; in almost every case far removed from the main single wires, and it is always arranged (or at least it ought to be) to have a main branch pass on either side of the compass, or run the branch near the compass double-wired. In every single-wired ship there are many places where double wires are run; no ship is entirely single-wired.

In so far as the danger to the compasses from magnetic leakage from the dynamos exists, it is equally the same whether the ship is double or single-wired.

The weak spots in any ship installation are the joints (always granted, of course, that good wires are used throughout). In a ship with 300 lights, double-wired, there will be probably about 700 soldered joints, that means about 700 points in wiring where the original insulation is cut off and re-insulated by the workmen. Another weakness in double-wired ships lies in the fittings. In these double contact fittings two wires are pulled through, and connected to the holders by screws. In these fittings the wires may make contact with the fitting, or with each other.

In single wiring we have the advantages arising from the fewer joints and less total length of main wires required, and also the advantages of using single wired fittings end central contact holders, these being much safer than double wire fittings and double contact holders.

In a double-wired* ship having 300 lights, there shall be about half the total length of wire and about half the number of joints. Now it is much easier maintaining the shorter wire in good order, and what is of greater importance, we can spend twice the amount of money on the insulation of the wire per yard, and we can spend twice the amount of money in making each joint. The making of thoroughly water-tight, reliable joints in a high-class insulated wire is a job one very seldom sees; it requires some skill, and therefore has to be paid for. The contractor who puts in single wiring can afford to put skill into his joints and first class wires and insulation into his installations; and, after all, these two points are the important ones in a ship installation — first class insulated wires and skillfully made joints—and, generally speaking, the less wire and fewer joints the better.

As to the accidents which sometimes occur, and *very nearly* originate a fire, these may arise from many causes on board a ship, quite apart from the nature of the wiring, that these cases have been made the occasion for making comparisons between English and American practice in American journals is to be regretted; but since they have been made, I may refer to them here. In the first place, the Americans are not a shipbuilding people, and have not had great opportunities of gaining experience in ship-lighting. I have seen their electric light wires and wiring, and on comparing them with the products of our leading makers on this side, come to the conclusion that we are consi-

* This seems to contradict the previous par.; should it not read single-wired? —EDS. ELEC. REV.

derably better off than they are. A wire equal to the best of our vulcanised rubber insulated wires is not to be got on the other side. The lead-covered wire *without a continuous insulation* of vulcanised rubber is a failure on board ship. Sea water is certain to get in between the wire and the lead pipe where there is no rubber insulation. In fact, if it were not for their high import duty, it would be better for American contractors to import their wires for ship-lighting.

There are scores of large ships single-wired, which have been crossing and recrossing the Atlantic in all weathers, some of them to my knowledge for six years, without either a derangement of the compass or an approach to a fire, and I have no doubt that Messrs. Siemens Brothers could give many instances of single-wired ships fitted by them years ago, in which not the slightest trouble has occurred. And, simply on the score of safety, many of the petroleum ships are single-wired. I know of eight or ten of them which have been running with single wiring for three years past without trouble.

Rankin Kennedy.

Polarising Conditions in a Galvanic Battery.

On reading an article by Prof. Dolbear which appeared in the ELECTRICAL REVIEW of the 14th November, I was much struck by some statements he made, because they are in direct opposition to what I have been led to consider—on the authority of one of our ablest electricians—to be the fundamental laws of voltaic electricity.

Prof. Dolbear says in his article, "When a piece of zinc is immersed in water it is found to be electrified, and its potential may be measured by a suitable electrometer;" and again, further on, "When a piece of carbon, or copper, or other element is placed in water, it exhibits similar electrical property." Now, is this the case? For is it not to "Volta" that we owe the discovery of a potential difference being set up, "*at* the point of contact," of two dissimilar metals?"

Surely, then, it follows from this, that by immersing either of the metals singly or together (but in this latter case not touching or connected in any way other than by the liquid), no potential difference is set up. At least, none adequate enough to account for the E.M.F. of the couple. When, however, one of these is brought into contact with the other, or with "any" dissimilar metal, *e.g.*, a gold ring, *then* a potential difference is immediately established. Being at present a young electrician, I am merely anxious to know how to reconcile these two diverse views, and I should be very glad if any of your readers would kindly inform me.

A. E. Gosset-Tanner.

November 29th, 1890.

[There is a considerable difference of opinion as to the real seat of electromotive force in the galvanic cell, but a single metal in contact with a liquid becomes polarised. "When a single metal is placed in contact with an electrolyte, a definite difference of potential is produced between the liquid and the metal. If zinc be plunged into water the zinc becomes negative, the water positive. Copper plunged into water also becomes negative, but much less so than zinc." (Jenkin's "Electricity and Magnetism," page 44.) We recommend you to study Chapter II. on "Potential," of Jenkin's book, from which the foregoing extract is taken.—EDS. ELEC. REV.].

Notes on Electric Lighting from Central Stations.

Herewith I enclose you for publication copy of letter received by me last week, dealing with statements made in my paper read before the Liverpool Engineering Society.

In putting this before you, I make no comment on the ideas held by the officials of the Silvertown Company, beyond that the data given by me was obtained on the spot, and that in each case I did my best to verify the statements attributed to me. We are all well aware of the success attending the underground system at Hastings, and it certainly reflects great credit, not only on the manufacturer of the cables in use there, but also on the engineers of the station, Mr. Mercer and his colleagues, that such exemption from troubles on the line has been obtained. With reference to high tension cables, I see no reason why cables insulated with material other than vulcanised rubber should not be equally fit to withstand the stresses brought to bear on the dielectric, and have reliable data to the effect that Messrs. Felten and Guilleaume have had some cables of special make under 10,000 volts for some time with perfect success. The Fowler-Waring Company are perfectly able to reply to any remark passed on their manufactures.

In reply to the Silvertown Company's query as to Callender cables, I simply stated that the Liverpool mains under the low tension in use here have proved most successful, and have, under adverse circumstances, maintained their high insulation. I am informed that at Batu a length of over five miles of Callender main has tested up to 50 megohms, and withstands easily 2,000 volts. I prefer to allow the engineers of the Liverpool Company to make more definite statements.

Charles H. Yeaman.

December 1st, 1890.

[COPY.]

The India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited, 54, Castle Street, Liverpool,
27th November, 1890.

C. H. Yeaman, Esq., Liverpool.

Dear Sir,—We are instructed by our London house to draw your attention to an article in the ELECTRICAL REVIEW, dated 21st inst., entitled "Notes on Central Station Electric Lighting," being a paper read by you in January last, before the Liverpool Engineering Society.

We have to point out that certain statements made therein are inaccurate. We are not asking that you should correct these publicly, but we write you that there may be no misunderstanding in future.

You only refer occasionally in the paper mentioned to underground cables, but in three of your references you are wrong.

In the first you say that all underground cables at Hastings are G.P. covered. About one-half are vulcanised rubber insulated cables supplied by us, and we understand that all future extensions will be carried out with this type of our Silvertown cable.

The Hastings Company write us, under date of July this year, "We have pleasure to report the success of the cable supplied by you to our company since the early part of 1884. Although we have several miles of your cable through iron pipes, corroded by the action of the sea and rain water, we have never had a fault, and there is no noticeable depreciation in the insulation resistance of 600 megohms per mile. The cables have been used for high tension currents connected to Brush machines at pressures from 1,500 to 2,000 volts."

At West Brompton, the Fowler-Waring cables on trial there have been abandoned, and our vulcanised rubber cables are exclusively used. With regard to the further statement that Mr. Ferranti has found that the Fowler-Waring cables are the only ones that will stand 10,000 volts pressure, a similar statement was made in a French paper, and we wrote to Mr. Ferranti, who replied to us as follows:—

"He certainly did not get the information from me that your cable broke down when tested with 10,000 volts. Certainly a number of cables did break down under varying pressures, and no cable was found which was sufficiently good electrically, and within the bounds of possibility commercially. Still, he should have mentioned that I applied to the Silvertown manufacturers, and did not receive which I wanted from them. I very much regret the trouble this has given you."

We believe the Fowler-Waring cables have been condemned the reason Mr. Ferranti did not order the 10,000-volts cable from us is that he did not consider that they were within the bounds of possibility, commercially.

In this we cannot agree with him until he produces, at a lower price, a cable that will work as successfully at this pressure as our own would.

As you are the City Electrical Engineer for Liverpool, we think we should put the above before you, and we beg to ask (as you appear to think highly of the Fowler-Waring cable), what is your experience with "Callender" cables?

Awaiting the favour of your reply,
We are, dear Sir,
Yours faithfully,
(Signed) R. T. CURRIE.
For the Company.